compendium of wonders of the natural world Clusius compiled in Leiden and published there in 1605.[17] That de Gheyn would have had access to a specimen of the *Diodon hystrix* in Leiden seems clear; moreover, the status of this fish as an object of curiosity at the time is amply documented.[18] How de Gheyn views the blowfish and the modes of verbal and visual description he engages to describe it are what is crucial here.

De Gheyn scanned the surface of the prickly orb of fish before him, first from in front of it and in line with its line of sight and then, in the rendering at the right of the sheet, from its right side. Finally, he scanned it again in order to record, in the inscription below, the shifting colors of its body. The continuity between the abbreviated and spiky forms of the drawing and the forms of the text below is suggestive, and the pace with which he describes the alterations of color from the back to the belly and from the fins to the body (the text is entirely without punctuation) is consistent with the sustained pattern of lines defining the fish above. Significantly, the descriptive responsibilities of the verbal and the visual accounts de Gheyn provides are distinct: the drawing of the fish conveys the form, and the inscription the color. De Gheyn's written description does not reiterate what is made visible in the accompanying image; it supplements it. And by describing the colors of the fish in the colors of pigments (Cologne earth, umber white, iron black grayish, yellow ochreish light gray) de Gheyn describes the fish *as a picture*.

De Gheyn's drawing offers a verbal description that is functionally distinct from the visual description it provides. His verbal description is of a different order—the order of color, of a painter's colors. The inscription does not allude to an external frame of reference beyond the palette, and in this sense the description de Gheyn proposes is entirely self-referential: "This fish" to which de Gheyn refers in the opening line of the inscription is no longer the fish hanging in the Leiden gallery, or the fish returned to the Netherlands after long voyages, the component of a collection of *naturalia*, or this fish as compared to any similar or other fish. "This fish" is the fish of de Gheyn's drawing, the fish of a picture in the making.

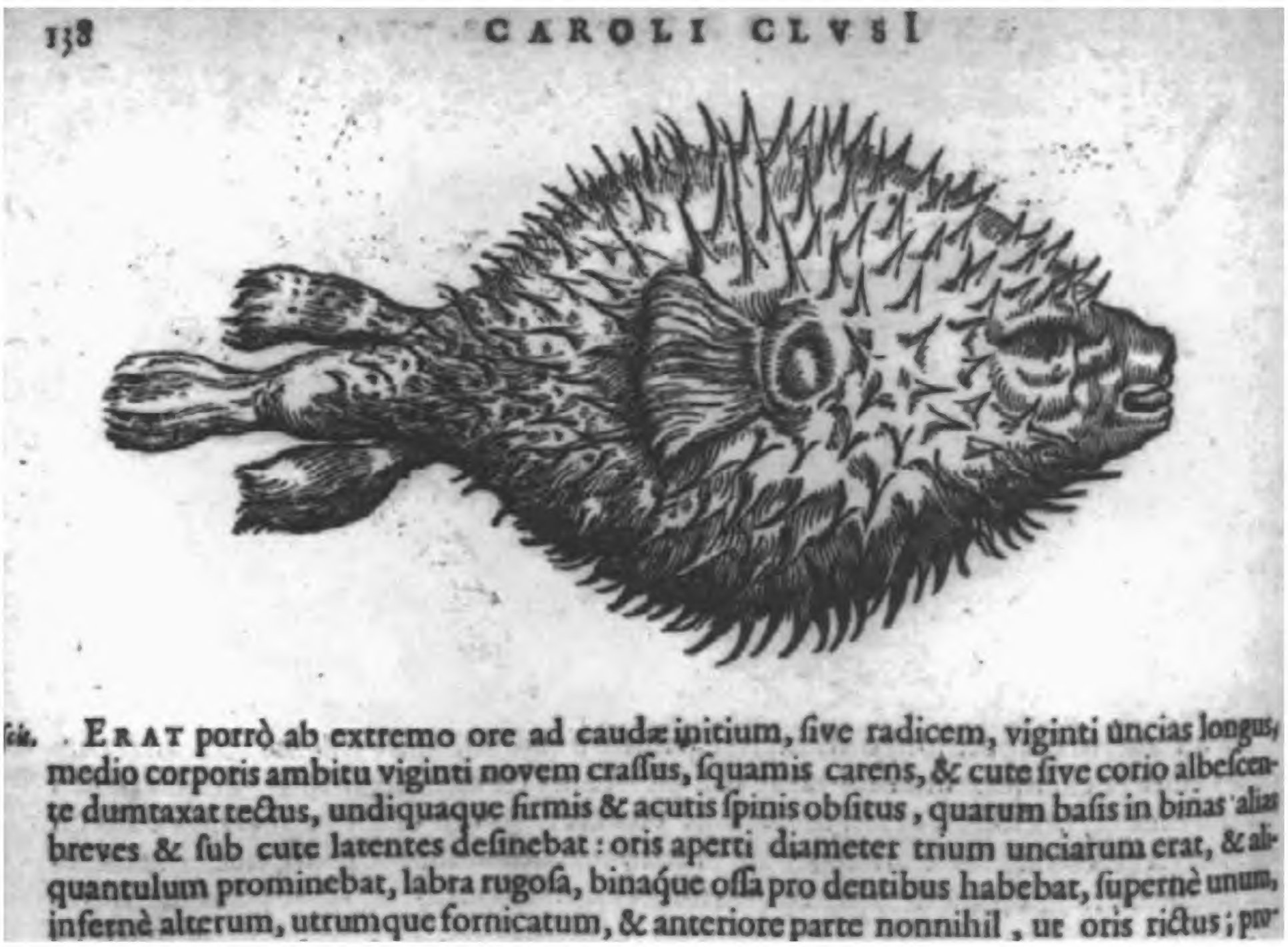
Reconstituted according to de Gheyn's indications—colored in—such a picture would effectively convey the forms and colors of this exotic natural specimen. To a very significant extent these were the characteristics according to which distinctions of class and sort were made within contemporary natural history.[19] That this is so is borne out in Clusius's accounts of the natural world in general, and in his description of the *Diodon hystrix* in particular, which is directly relevant to assessing the status of de Gheyn's description. In his voluminous *Exoticorum*, Clusius documents the four fish he identifies as blowfish in the course of four separate chapters of book 6. Of the first three of the fish he describes, Clusius writes that he had observed them hanging in "museums" belonging to individuals in Amsterdam and in Montpellier.[20]

Each of Clusius's entries on these four fish—what he calls the *Histrix piscis* and three related fish, which, following Guillaume Rondelet, the French icthyologist, he names the *Orbis spinosus*, the *Orbis muricatus*, and the *Orbis muricatus alter*—is accompanied by a woodcut that represents the fish described (figs. 4.4, 4.5, 4.6, and 4.7).[21]

In his text, Clusius makes reference to drawings that served him variously in the process of classifying the specimens he describes. One acquaintance, Jacob Plateau, donated drawings of two of the fish;[22] the Leiden pharmacist Christian Porret is credited with having provided Clusius with another.[23] At one point Clusius states that a drawing was made for him to enable him to compare specimens.[24] Clusius's dependence on images in the course of assembling his account of the *Diodon hystrix* is noteworthy; that each of his entries is illustrated with a woodcut reflects a conviction, amplified in his text, that images convey information crucial to description and some form of rudimentary classification. Within the context of late sixteenth-century natural history, the combination of text and image here is entirely conventional. But if Clusius's descriptive method exemplifies the industry standard insofar as it corresponds to the manner in which verbal and visual description are coupled throughout natural history writing of the time, his account of these four fish also provides an excellent example of the limits of contemporary classificatory strategies.

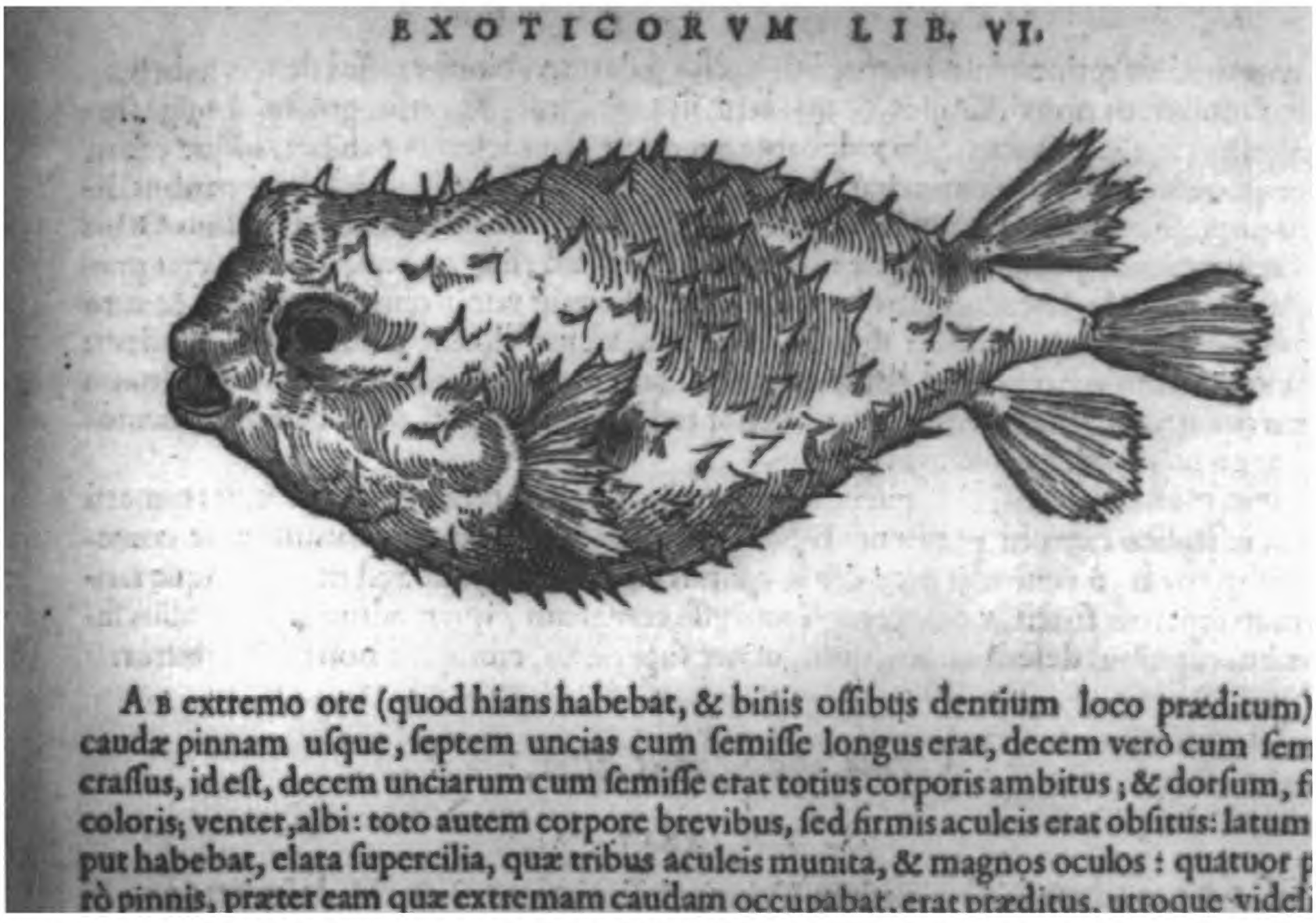
The degree to which Clusius relies on external, observable characteristics in order to describe and classify the specimens he records is typical of contemporary natural history. Clusius's verbal description of the *Histrix piscis*, for example (fig. 4.4), amounts to a meditation on the impenetrable surface of the spiny fish. Its dimensions are given, measured from its shriveled lips to the root of its tail and around its center, and then the specimen is, as it were, fleshed out by a description that dwells on its superficial characteristics. He seems to write as he scans the object: it is "without scales and covered merely with a whitish skin or hide, strewn with firm and sharp spines on all sides." A description of its somewhat protuberant mouth and wrinkled lips and teeth follows, with conjectures about the predatory techniques of the fish; from the eyes, with their raised eyebrows and four prickly spines, Clusius moves along the body. The dimensions of the fins and the coloration of the body are noted ("the skin of the belly is white, and the back is dark, with many distinct dark spots") and, finally, the orifice through which the fish is thought to breathe and the differing inclinations of its spines are recorded.[25] Ultimately, he informs the reader that he is unable to discuss the internal structure of the fish, which was not native to local waters, because it was available to him only in dried form.[26]

If on the one hand the lack of live blowfish in the Netherlands compounded their exoticism, it also made for highly unstable classification.[27] Depending on



. ERAT porrò ab extremo ore ad caudæ initium, ſive radicem, viginti uncias longus, medio corporis ambitu viginti novem craſſus, ſquamis carens, & cute ſive corio albeſcente dumtaxat tectus, undiquaque firmis & acutis ſpinis obſitus, quarum baſis in binas alias breves & ſub cute latentes deſinebat: oris aperti diameter trium unciarum erat, & aliquantulum prominebat, labra rugoſa, binaque oſſa pro dentibus habebat, ſupernè unum, infernè alterum, utrumque fornicatum, & anteriore parte nonnihil, ut oris rictus; pro-

Figure 4.4 Anonymous, *"Histrix Pisicis,"* woodcut in Carolus Clusius, *Exoticorum Libri decem*, Leiden, 1605. Photo courtesy of the National Herbarium of the Netherlands, Leiden.



A B extremo ore (quod hians habebat, & binis oſſibus dentium loco præditum) caudæ pinnam uſque, ſeptem uncias cum ſemiſſe longus erat, decem verò cum ſem craſſus, id eſt, decem unciarum cum ſemiſſe erat totius corporis ambitus; & dorſum, f coloris; venter, albi: toto autem corpore brevibus, ſed firmis aculeis erat obſitus: latum put habebat, elata ſupercilia, quæ tribus aculeis munita, & magnos oculos: quatuor p rò pinnis, præter eam quæ extremam caudam occupabat, erat præditus, utroque videl

Figure 4.5 Anonymous, *"Orbis spinosus,"* woodcut in Carolus Clusius, *Exoticorum Libri decem*, Leiden, 1605. Photo courtesy of the National Herbarium of the Netherlands, Leiden.

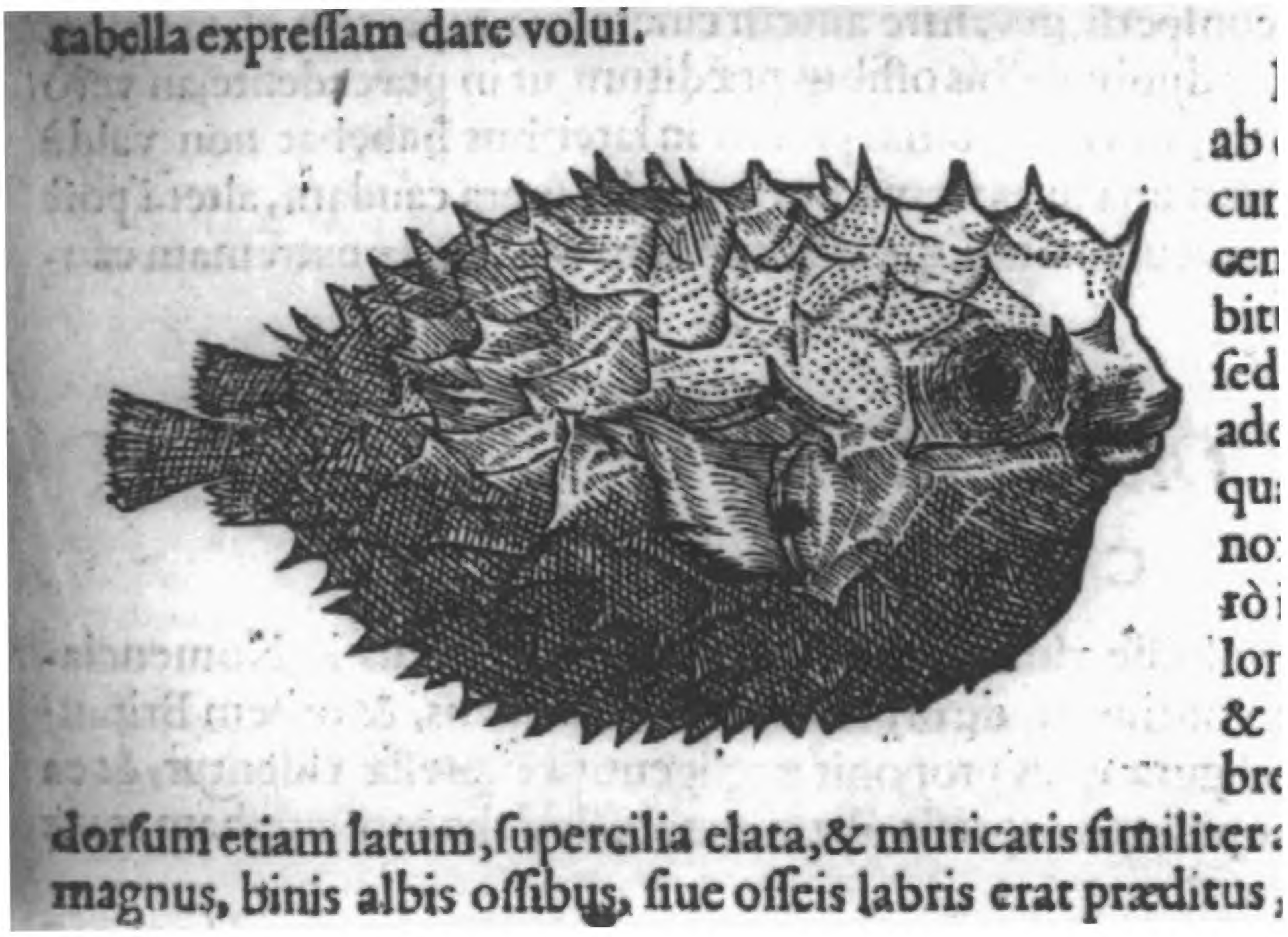


Figure 4.6 Anonymous, "*Orbis muricatus,*" woodcut in Carolus Clusius, *Exoticorum Libri decem*, Leiden, 1605. Photo courtesy of the National Herbarium of the Netherlands, Leiden.

the conditions under which they were imported, specimens were not always intact, or they had been carelessly dried and so were deformed. To Clusius and his contemporaries, variegation of form, however, pointed to differences of biological sort or kind, rather than to the uncontrolled means of procuring specimens. In fact, the four fish Clusius describes and names individually are probably all of a single species—the *Diodon hystrix*. It is on the basis of external, visible, quantifiable characteristics that Clusius isolated what he perceived to be four separate kinds of fish, and his dependence on images in the classification of varieties of the *Orbis* demonstrates this to a fault.

Throughout Clusius's *Exoticorum*, as also in most contemporary natural history publications, images served to complement verbal description; they also, where they were the only available evidence, served as a basis for it, as well as for classification. Insofar as the criteria for classification Clusius uses are reducible to form and color, they amount to information an image can impart. It is especially significant that, within Clusius's account of these types of fish, the *Orbis muricatus alter* (fig. 4.7) is recorded as a variant solely on the basis of an image provided by an acquaintance. It was not possible, Clusius writes, for him to observe this particular fish, "but I received from Jacob Plateau a colored picture of it." This image was later supplemented,

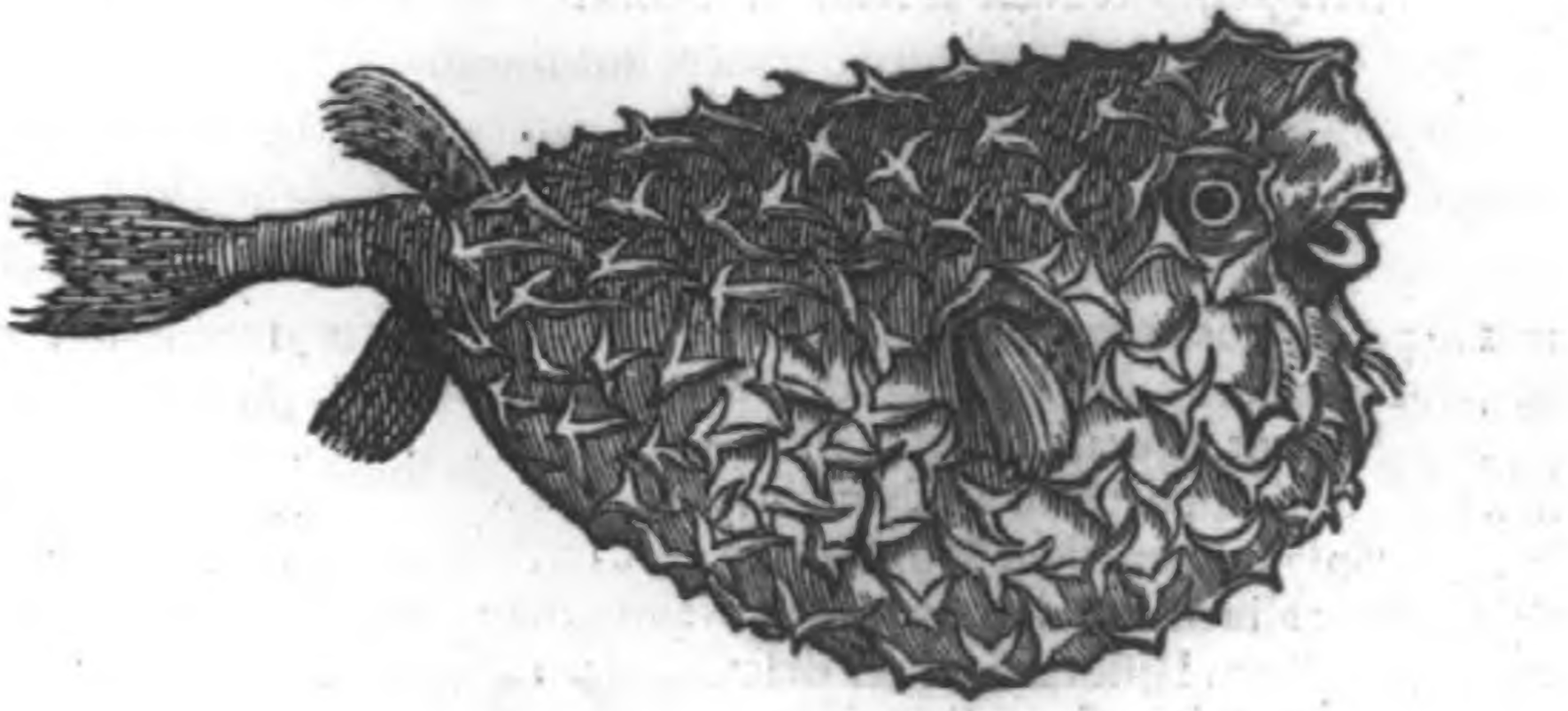


Figure 4.7 Anonymous, *"Orbis muricatus alter,"* woodcut in Carolus Clusius, *Exoticorum Libri decem*, Leiden, 1605. Photo courtesy of the National Herbarium of the Netherlands, Leiden.

Clusius notes, by information Plateau provided regarding the dimensions of the fish.[28] Because the criteria for classification Clusius engages are more or less exclusively descriptive and quantitative, images may even play a subversive role: classificatory strategies were woven around images taken on faith.

That Clusius depended on images to supply him with the information necessary for purposes of classification is evident in his works on the plant world as well. Given Michel Foucault's arguments for the "epistemological precedence enjoyed by botany" among the natural sciences of the classical age, it is perhaps surprising that Clusius should have relied on images of fish to the extent that he did. Foucault writes:

> The area common to words and things constituted a much more accommodating, a much less 'black' grid for plants than for animals; in so far as there are a great many constituent organs visible in a plant that are not so in animals, taxonomic knowledge based upon immediately perceptible variables was richer and more coherent in the botanical order than in the zoological. . . . Because it was possible to know and to say only within a taxonomic area of visibility, the knowledge of plants was bound to prove more extensive than that of animals.[29]

In his works on plants, which culminated in the publication in 1601 of his *Rariorum Plantarum Historia*, Clusius supplemented his descriptions of flowers, for example, with considerations on relative scale, the time of the year they blossom, and their provenance; but the characteristics most crucial to their classification are those that can be observed in the immediate presence of the specimen.[30] Or, as we have seen in the case of the *Orbis muricatus alter*, those that can be recorded pictorially. In his groundbreaking chapter on tulips in the *Rariorum*, Clusius describes a variety of dwarf tulip within the category of the "intermediates"; it blossoms between the "early" and the "late" varieties. This class is described generally as follows:

> The dwarf [intermediate] tulip is not more than a foot high, usually even less, and in its leaves and flower it strongly resembles the early tulip. All its segments are pointed, but the outer ones are much longer, externally dull red but at the outermost margins greenish; the inner segments are of a brilliant, fiery red throughout. The claws are yellow and radiating, but marked with a jet-black patch in such a way that the latter appears encircled by a mere golden aureole and bears some likeness to an eye; the filaments and their anthers are blackish. It should be noted that its bulbous root is woolly; the outer membrane enveloping and covering the substance of the bulb is so tightly filled with an abundance of dense, white, soft stuffing that it must form a very soft resting place for the bulb.[31]

From the opening sentence of his description, Clusius moves the reader to imagine the plant described. The dwarf tulip resembles the early tulip in its overall appearance; and in the more specific rendering of the appearance of this flower, we are led from part to part by gradations and shifts of color. At the center of the plant, and of the description, we encounter in an almost specular manner (we are looking into the tulip from above, observing the appearance of the golden aureole) "some likeness to an eye." The sensual engagement with the object, which culminates in an empathic description of the outer membrane of the bulb ("a very soft resting place" for it) is driven by a single organ—the eye.

One further example of the dwarf tulip is discussed by Clusius in the text immediately following that cited above. Here again, as in the case of the *Orbis muricatus alter*, Clusius incorporates this specimen into his account on the basis of an image alone, and in the absence of actual experience of the specimen. "Also another kind of dwarf tulips is found," he writes, "which, however, I have not seen."

> But I received a drawing in natural colors ["*iconem suis coloribus expressam*"] of it in the year 1596 from the learned Johan de Jonge, Minister at Middelburg, to which had been added the following description:

> "I send you a picture ['*contrefeytsel*'] of a certain tulip, drawn after the plant itself, that is to say of natural size in regard to the plant as well as to the stalk, the flower, the leaves (which should have been drawn slightly longer and narrower) and the bulb, which I dug up in order to enable the artist to properly draw it. . . . "

The whole plant, then (as far as I have been able to gather from the drawing), is not bigger than the palm of a hand, producing four narrow, keeled leaves resembling those of the Montpellier tulip, from among which arises a little stalk of the height of an inch or a little higher, leafless (in contradistinction to the habit of other tulips), purplish green, and carrying on its top a flower consisting of six segments, externally somewhat purplish, internally whitish, its center occupied by an oblong pistil fenced in by six yellow little stamens. . . . That it has flowered in April I deduce from the fact that my correspondent sent me the drawing by the beginning of May.[32]

Sustained observation and morphological comparison are the means to classification, and to the extent that these processes depend on the visual aspects of the specimen to be classed, an image "drawn after the plant itself" and "in natural colors" was deemed sufficient to supply the necessary information.

Such images as Clusius cites and publishes mark the limits of his analysis, which depended crucially on visually apprehensible information. The case of Clusius is exceptional to a degree: unlike many of his contemporaries, he had relatively little interest in the pharmaceutical properties of the plants and other natural objects he described. In fact, it is Clusius who is most renowned for having studied and cultivated rare and exotic species of flowers — tulips, lilies, and other foreign bulbous varieties — as curiosities rather than as remedies. This is not to say that the images he relied on were any different from the images his fellow "fathers of Netherlandish botany" Rembertus Dodonaeus (1517–85) or Matthias Lobelius (1538–16), for example, included in their voluminous accounts of the plant world. Indeed, many of the woodcuts in Clusius's publication were printed from woodblocks in the possession of his publisher Cristoffel Plantin that were also used in Dodonaeus's and Lobelius's great herbals.[33] Clusius's taxonomic efforts, though, were driven by morphological rather than utilitarian (pharmaceutical) concerns. And in this sense images could be said to play a distinct role in his efforts, in principle if not always in fact.

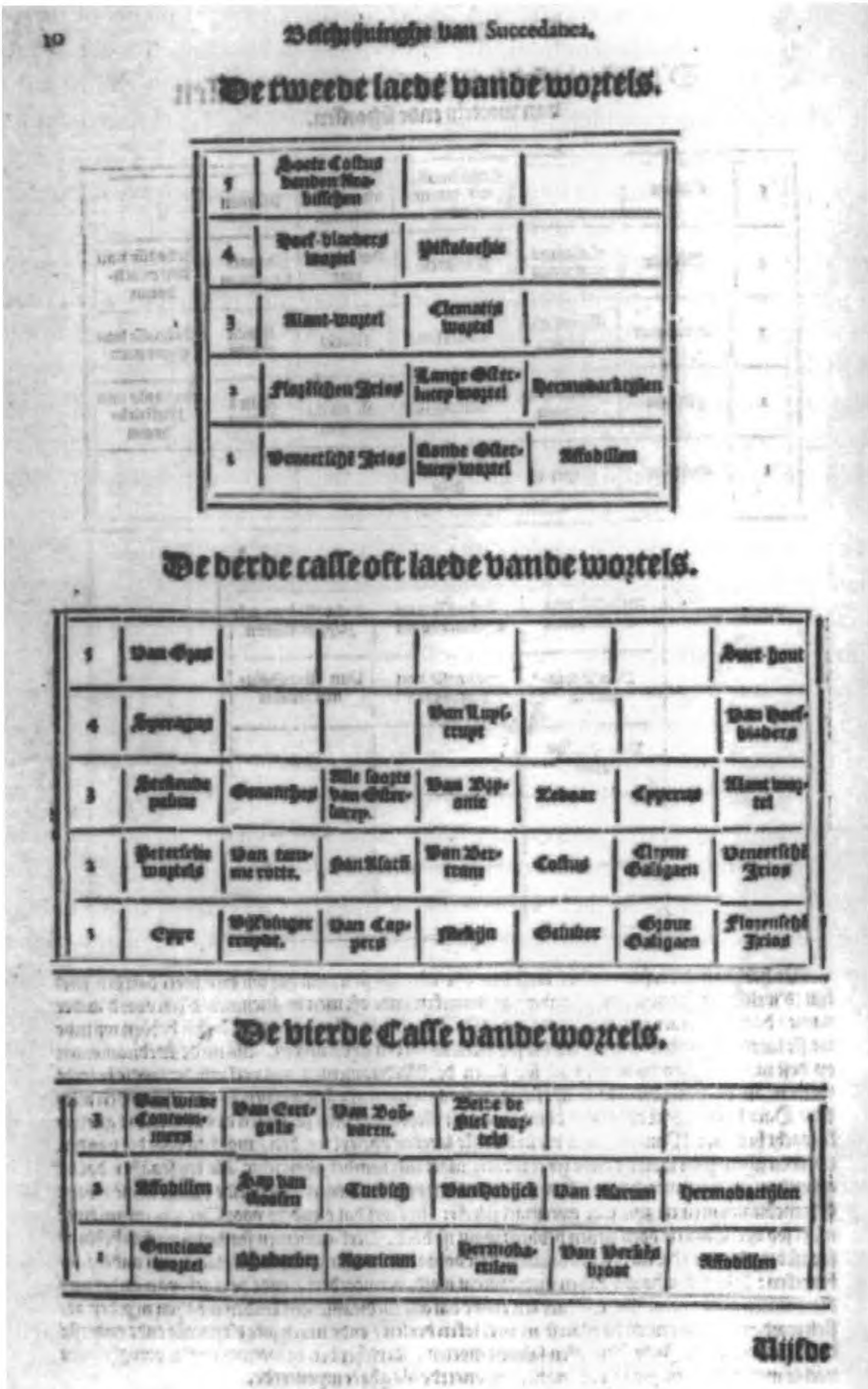
There are two crucial differences between Clusius's verbal description of the "porcupine fish" and de Gheyn's inscription on his drawing of the *Zee-Eeghel*. De Gheyn shows no concern with the dimensions of the fish or its

origins or the relation of this dried specimen to the living fish; and the terms in which he describes its coloration are in effect painterly. It is in the verbal, not the visual, information imparted by de Gheyn's image that we can locate its functional prerogatives; it is only its inscription that distinguishes de Gheyn's image from those published by Clusius. It should be clear from the foregoing that sixteenth-century natural history depended on morphological description to such an extent that it would have allowed for the assimilation of precisely this kind of image for scientific ends. Nothing is intrinsically scientific about either de Gheyn's or any of Clusius's or his acquaintances' images; they are capable of being impressed into service of a scientific kind. They become the labels, in a sense, behind which names may be stored.

This circular tale is intended to call attention to the ways in which naturalistic representation served and furthered the ends of a natural history concerned, as Foucault put it, with "the nomination of the visible."[34] Elsewhere, I have written at some length about the role of verifiably naturalistic images—images that could stand in for what they represent—in natural history of this period.[35] I want now to call attention to a different form of visual representation common, not to say integral, to this natural history. This is the grid, the schematic, rectangular representation that so very frequently occurs in the context of the practice and publication of natural history in the sixteenth and early seventeenth centuries.

TABULATION

It is difficult, when examining the relations between visual representation and the praxis of natural history in the early modern period, to overlook the grid and its affiliate, the tabular diagram.[36] Examples abound. Matthias Lobelius's 1581 volume on plants, one of the most renowned botanical publications of its time, concludes with a striking section, "Vande Succedanea," which consists principally of a series of nearly twenty schematic grids (fig. 4.8).[37] Lobelius's herbal shares the distinction, with the publications of his contemporaries Dodonaeus and Clusius, of being copiously illustrated—each of the roughly thirteen hundred pages of text contains at least two woodcuts. The grids in the concluding section of the book come as something of a surprise, given the predominance of naturalistic images overall. The title of this last section of Lobelius's voluminous publication specifies that the individual tables illustrate which dried substances—herbs, roots, flowers, seeds, resins, gums, stones, woods—may be substituted for others for medicinal ends. Lobelius's grids or "tables," as he calls them, offer suggestions for the organization of dried specimens in what Aldrovandi called



De tweede laede vande wortels.

5	Soete Costus vanden Arabischen		
4	Hoef-bladers wortel	Pistolochie	
3	Alant-wortel	Clematis wortel	
2	Florentschen Irios	Lange Oster-lucey wortel	Hermodactylen
1	Venetische Irios	Ronde Oster-lucey wortel	Affodillen

De derde casse oft laede vande wortels.

5	Van Gyns						Soet-hout
4	Asperagus			Van Lupscruyt			Van Hoefbladers
3	Herkende palme	Oenanthes	Alle soorte van Oster-lucey.	Van Pyonie	Zedoar	Cyperus	Alant wortel
2	Petersilie wortels	Van tamme roote.	Van Alarck	Van Bertram	Costus	Cleyne Galigaen	Venetische Irios
1	Eppe	Wijnstinger cruydt.	Van Cappers	Mekijn	Galiber	Groote Galigaen	Florentsche Irios

De vierde Casse vande wortels.

3	Van wilde Comkommers	Van Centgals	Van Bosvaren.	Witte de Bies wortels		
2	Affodillen	Hop van Goosen	Turbith	Van Dodijck	Van Alarum	Hermodactylen
1	Gentiane wortel	Rhabarber	Agaricum	Hermodactylen	Van Veckle broot	Affodillen

Tijsde

Figure 4.8 Anonymous, woodcut in Mathias Lobelius, *Kruydtboeck*, Antwerp, 1581. Photo courtesy of the National Herbarium of the Netherlands, Leiden.

"pigeonholes"—that is, compartments or drawers in larger pieces of furniture. The pigeonholes schematically represented in the Lobelius woodcuts were intended to correspond to the drawers of a pharmacist's cabinet; the scheme according to which their contents are ordered is a functional—and distinctly pharmaceutical—one.

The kinds of specimens itemized in these woodcuts were, as we have seen in both Aldrovandi's case and the case of the Leiden botanical garden, collected and studied in the immediate proximity of living specimens—plants in particular. The basic units of the Leiden University garden (figs. 4.2, 4.3) are similar to those of numerous early modern academic gardens: multiple individual plots, which in Leiden were arranged in larger rectangular beds. They are itemized and numbered in the plot at the lower left of de Gheyn's plan and in the plot at the far lower left of the upper left quadrant (fig. 4.2). Each small plot of the Leiden garden—in 1594, there were fourteen hundred—contained five specimens at most, and generally speaking one or two.[38] None of those specimens, incidentally, is represented in de Gheyn's plan of the garden. This is particularly interesting in light of the fact that this engraving was produced in conjunction with Professor Pieter Pauw's publication, in 1601, of a catalog of the "Hortus publicus" or public garden.[39] Pauw's is a strange catalog, for it consists of a text preface followed by pages and pages of sets of rectangular boxes (fig. 4.9).[40] Pauw explains in the preface that students of plants were to adapt the catalog to their own experience—to take it with them to the garden and to fill in the rectangles with the names of the plants growing in the rectangular plots of the garden. The space of phytographic experience was, indeed, the rectangular grid. Active phytographs translated their experience of the plots de Gheyn represents in bird's-eye view into the spatially coordinated charts, or tables, of the plants the plots contained. This translation corresponds more or less directly to the way in which the contents of Lobelius's herbal—a series of individual, naturalistic descriptions of plants—are staged against the pigeonholes of the schematic cabinet.

The assemblages of medicinal, protobotanical, zoological, icthyological, ethnographic, mineralogical data such as we know Aldrovandi to have cultivated, and medical professionals throughout Europe in the sixteenth and seventeenth centuries to have studied, were consistently structured and represented by way of the grid. The great and widely traveled Dutch doctor Bernardus Paludanus (1550–1633), for example, amassed a collection of *naturalia* (plant, animal, and mineral specimens) and *artificialia* (primarily ethnographic specimens) at the end of sixteenth century that, although holed away in the northern port town of Enkhuizen, was renowned throughout Europe.[41] In a series of brilliant protocapitalist moves he sold, reconstructed,

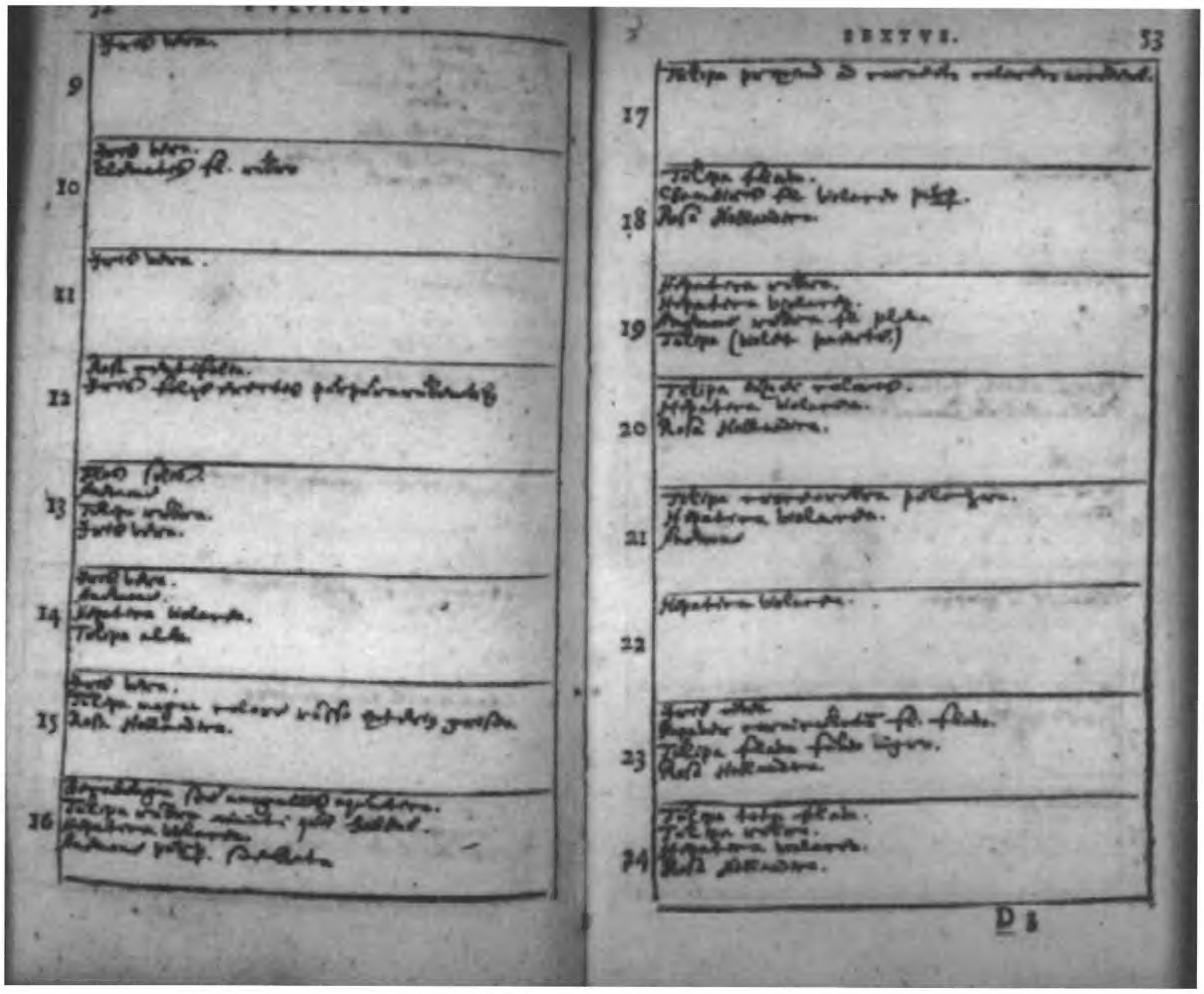


Figure 4.9 Pieter Pauw, *Hortus Publicus*, Leiden, 1601, pp. 52-53. Photo courtesy of the National Herbarium of the Netherlands, Leiden.

and sold again his curiosities, dried animals, minerals, fossils, plants, tusks, and so forth. His collection was the focus of intense admiration on the part of foreigners and native Hollanders alike; hardly a naturalist of the time failed to mention, let alone pay homage to or visit, Paludanus's collection, and the total number of visitors is in the thousands. An elaborate description of Paludanus's collection was compiled by Friedrich of Wurtemberg (1557–1608), one of the doctor's many distinguished guests. The future duke, who was at the time of his visit expanding his own *Wunderkammer* in France, published a catalog of the contents of the Enkhuizen collection in 1603.[42] Notably, it consists of several pages of grids, in which the contents of the collection are itemized (fig. 4.10). These grids seem to correspond to the actual storage of the specimens in the collection, in cabinets or drawers; in all likelihood, Friedrich transcribed the collection in this manner in order to transpose it to his own.

The reason for the widespread use of grids may well be directly related to the problem evident in Aldrovandi's description of his own collection:

Myrrhinum sive Murrhinum vasculum India extrema Orientalis vulgo porcellanâ vocant.	*Vasculum fictile artificiosum flavum Italicum eleganter pictum.*	*Vasculum aliud ex Chynarum regione minus priore.*

Vasculum antiquissimum ex Lemnia sphragide pretiosum.	*Vasculum aliud fictile candidum pisanum.*	*Murrhinum vasculum Chinitanum elegantur pictum valdè parvum.*	*Pars quædam vasculi antiqui rubra elegantèr picta.*
Vasculum aliud fictile nationum domo Illustriss. Principis Friderici Comitis VVirtembergici.	*Pocalia VValdenburgica.*	*Vasculum liquationis & separationis metallorum candidum Numantinum.*	*Vasculum aliud nigrum liquationis.*

Vitrum antiquissimum triangulare cum effigie antiquissima.	*Cylindri purif. ex Crystallo nativo fossili vero.*

Flos alius vitreus elegantissimus.	*Dominæ effigies vitrea vitro aqua plena inclusa.*	*Alius flos ex vitro coloribus tinctis.*	*Conspicillum ex Crystallo montana vera.*
Terna alia navicula minutæ ex vitro.	*Lucretiæ Romanæ effigies vitrea.*	*Ornamenta vitrea.*	*Vitrum fractum Gallicum aereum.*
Antimonium præparatum.	*Fibulæ elegantes ex vitro minutæ.*	*Clepsydra vitrea parva elegans.*	*Vitrum aliud nigrum fractum.*
Globus ex vitro variegatus elegantiss.	*Cinerea kaly Alexandrini unde fit vitrum.*	*Cineres herbæ kaly alij unde fit vitrum.*	*Vitrum fractum candidum.*
Sphærula sive coralli differentes ex vitro.	*Ornamenta seu fibulæ quæ auribus appenduntur ex vitro.*	*Gelosiæ vitreum est quæ olim parietes incrustabant.*	*Speculum vitreum.*

N S E.

Figure 4.10 *Wurhaffte Beschreibung zweyer Raisung*, Tübingen, 1603. Photo courtesy of Amsterdam University Library (ZKW).

> Where to put it all? How to pigeonhole the vast ranges of data and specimens that were accumulated? The grid asserts no necessary genetic or relational order between the things it organizes and, crucially, it is infinitely expansive. Nonhierarchical and nonchronological, the grid allowed for precisely the kind of serial differentiation that drove natural history at this moment in its development.

Generally speaking, the death of the naturalist Conrad Gessner (1516–65) is lamented as untimely and said to have deprived contemporary natural history of one of its greatest agents.[43] In a sense, his death by plague was productive, for it encouraged a posthumous production—edited by friends and hangers-on—that invokes and represents Gessner's efforts in telling ways. In 1587, Caspar Wolf (1532–1601), a student of Gessner's and his successor as municipal physician in Zurich, published a handbook under Gessner's name, called *De Stirpium Collectione Tabulae tum Generales, tum per duodecim menses . . .*, or "The general and annual tables for the collection of plants."[44] This small volume consists entirely of a series of lists, called tables. Page after page contains a typographically sparse accumulation of names and various qualities of plants. Wolf's volume is divided into four parts, each of which amounts to a different organizational grid, mapped onto the plant world. The first part, called "The General Table of Plants," contains enumerations of the sorts and parts of plants, which serve as means for differentiating them.[45] The qualities surveyed range from "Substance," which covers both the type of plant (tree, herb, fruit, legume, and so on) and its "constitution" (hard, soft, dense, fragile) to "Quantity," and "Qualities of the Object," to "Location" (where it grows), and, finally, "Virtues" and "Uses." The remaining sections of the book are: "On the Collection of Plants in General," which provides general instructions on when to pick and how to dry plants and seeds;[46] "The First Table of Plants, Flowers and Fruits, enumerated in alphabetical order," a list of plants, by Latin name, with indications of when the plants flower, bear fruit, and seed;[47] and "The Second Table, containing plant names in German and in Latin," which is organized according to the months of the year, and in which the plants are listed according to when they flower, bear fruit, and seed.[48] What do these "tables" add up to? Generally speaking, they provide evidence of the extent to which the tabular model—the serial categorization of entities—structured the experience of the natural world, for Gessner as for Wolf. In the final section of Wolf's handbook, one rudimentary scheme of classification (*Tempus*, or when plants mature) is crossed with another—the alphabet. That overlay of schemes is indicative, of the consistency with which use (and specifically medicinal or pharmaceutical application) structures natural historical experience. Wolf's preface to this volume contains the following specification for "The Use of these Tables":

> These tables will be useful not only for those concerned with pharmacy, or for apprentices to this science, but for all those who have an interest in the study of plants. All those who enjoy, be it winter, summer, or fall, going out in the countryside, following partly their own impulse toward knowledge, and partly driven by the necessity of taking a break and exercising their own bodies—let them take the opportunity, thanks to these tables, to go looking for plants, those they know, and to hope to find new ones.[49]

Here, as in the case of Pauw's interactive catalog of the Leiden garden, a tabular model or grid structures experience of the natural world.

Very much remains to be said about early modern classification. Generally speaking, the period under discussion, the later sixteenth century, is just about the time in which a medicinal, pharmaceutical, use-oriented botany gives way to a more purely morphological botany. As mentioned earlier, Carolus Clusius is often cited as a primary agent of this shift. What is implicit in such claims for a transition from a more or less alchemical relation to the natural world—What are its intrinsic properties? What can it do for me?—to a pre-Linnaean move to systematically account for the natural world, is that the transition brings order with it. One of the aims of this article has been to demonstrate that a certain order—visually represented by the grid—was already operative; recuperating it and reconstructing its applications are crucial in understanding early modern experience, and representations, of the natural world. The coordinates of this order might be reduced to serial differentiation; above all the grid allows for comparison of specimens, which have been extrapolated from their "native" contexts and offered up to the language of Gessner and Wolf, for example. Are such specimens soft? Hard? Oily? Dry? Two-part? Three-part? Trees? Legumes?

The grid or tabular model of organization is artificial and schematic, but not necessarily hierarchical. It is, rather, serial. What is perhaps most remarkable about this mode of natural historical observation and schematization is that it is fundamentally nonconclusive. Just because the vanilla bean is long, brown, and contains a certain number of seeds does not legitimate placing it in any privileged relation to other beans, seeds, or foreign plants. The market will do that. This brings us to a class of images I want to adduce by way of conclusion. More or less contemporaneously with the blowfish and the grids discussed here, a "new" genre of painting emerged full force in northern Europe. The first decade of the seventeenth century saw the production of a significant number of these paintings, which conform in technique and subject matter, and had not previously been widely produced or generally marketable. By the mid-seventeenth century, they were countless. Jacques de Gheyn II himself is credited with having painted one of the first three. This "new" genre is the flower still-life painting which

Figure 4.11 Jacques de Gheyn II, *Flowers in a vase and small animals*, watercolor and gouache on vellum, 1600. Photo courtesy of the Fondation Custodia (Coll. F. Lugt), Institut Néerlandais, Paris.

typically, in the early years, consists of numerous flowers gathered together in isolation, and offered statically to the viewer's gaze.[50]

The flower still-life attests to sustained interest in naturalistic representation of the blowfish kind; each painstakingly rendered specimen stands in for its real counterpart and, taken together, they come to be referred to as microcosmic representations of gardens (see fig. 4.11). Simultaneously, it makes sense to think about the structure of these pictures, and of their viewing, as pertaining to the tabular model. Consider, for example, that many of the flower still-life paintings, or botanical portraits, produced in the early seventeenth century consist of vases filled with more stems than could readily be fit into the vases and that the flowers represented are more often than not shown blossoming simultaneously, whereas in fact, or in nature, they do not. The counternaturalistic impact of these pictures is crucial. If these paintings were — initially at least, in the first decades of the seventeenth century — painted and collected as "botanical portraits,"[51] and served to record and preserve the appearance of the individual specimens so carefully arranged, to what degree does the sequential, nonnarrative structure of such

pictures bear comparison with the grids and tables of natural historical experience? Conventional art historical interpretations have read these images—the flower still-life paintings of the early seventeenth century—as allegories of vanity and the brevity of life.[52] By way of a counterproposal, I want to cite a passage from a philosophical dialogue written in the 1580s by the great neo-Stoic Justus Lipsius (1547–1606), which goes some way in suggesting that attempting to recuperate modes of experience might be more productive than insisting on emblematic or allegorical readings of paintings of the natural world. And that the apparently disjunctive range of scientific representation I have cited—from naturalistic renderings of blowfish and tulips to schematic diagrams of gardens—are not only compatible, but inseparable.

This passage is from Lipsius's *De Constantia*, a dialogue that takes place in a garden, as befits a good Erasmian encounter.[53] The garden of *De Constantia* may well be fictional, but the story of Lipsius's actual gardens is entirely relevant to the foregoing. Lipsius, from the city of Louvain in the southern Netherlands, was professor at the Leiden University from 1578 until 1591.[54] When Lipsius left Leiden, he left two gardens behind, one of which was impressed into immediate service as the university teaching garden before the plots of that garden were dug in 1594, and the official garden opened.[55] Lipsius writes:

> Observe for me these numerous flowers/ how they grow: how these are brought out of their sheaths/ those out of their buds/ see how this one dies suddenly and falls down/ and another one grows on its stem. Finally/ see how one sort of flower is distinguished from and can be compared to/ thousands of others/ solely on the basis of its form/ color, and appearance/. . . . Now/ bring your scrupulous eyes here/ and regard for a moment this sheen and the beautiful colors. See/ how this flower [is] a beautiful purple in color/ this one blood red/ this snow white/ this one like a flame/ this shines like gold . . . even the very best painter cannot possibly replicate them . . . Would that God would allow me to live peaceably among these treasures. . . . among these flowers of the known and the new unknown world.[56]

For Lipsius, the garden is a spectacle, a source of wonder. He encourages "scrupulous eyes" to follow the forms of the individual plants as they change over time and as they vary from one to the next. The "treasures . . . of the known and new unknown world" offer their incomparable colors and sheen for careful, sustained observation. The terms of Lipsius's description are fairly pat; where he lapses into simile it is to compare the coloring of the flowers to gold or to fire—the visible properties of these treasures exceed the products of humans, and of the painter in particular. At the same time,

he invokes specific patterns of observation when he states that each sort of flower can be distinguished from and compared to others on the basis of its visually apprehensible, external characteristics. It is this comparative morphology that motivates the use of naturalistic representations (which will strive to equal the "sheen and beautiful colors" Lipsius records) and, at the same time, drives the tabulation of the natural world.

Notes

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1. See, principally, Sandra Tugnoli Pattaro, *Metodo e sistema delle scienze nel pensiero di Ulisse Aldrovandi* (Bologna: Cooperativa Libraria Universitaria Editrice Bologna, 1981); Giuseppe Olmi, *L'inventario del mondo. Catalogazione della natura e luoghi del sapere nella prima età moderna* (Bologna: Il Mulino, 1992); Paula Findlen, *Possessing Nature. Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley and Los Angeles: University of California Press, 1994).

2. As quoted by Giuseppe Olmi, "Arte e Natura nel Cinquecento Bolognese: Ulisse Aldrovandi e la Raffigurazione Scientifica," in *Le Arti a Bologna e in Emilia dal XVI al XVIII secolo. Atti del XXIV Congresso Internazionale di Storia dell'Arte*, ed. Andrea Emiliani, 4 vols. (Bologna: CLUEB, 1982), 4: 151–173, esp. 151.

3. See, e.g., Pattaro, *Metodo e sistema*, 19: "Infine, come esempio del procedimento (*modus*) col quale l'Aldrovandi tentò di realizzare il proprio ideale erudito ed enciclopedico, si può portare la sua *Selva universale della scienze* o *Pandechion epistemonicon* [unpublished]. Quest'opera, che fu completata nel 1589, è una sorta di dizionario, in ottantatre volumi, ove le materie piú disparate sone prese in esame per ordine alfabetico con amplissimo corredo di riferimenti e d'informazioni, e fu concepita esplicitamente dal naturalista bolognese affinché fosse di guida a chiunque desiderasse 'sapere o comporre sopra qual si voglia cosa naturale o artificiale,' onde trovare 'a quel proposito quel che n'hanno scritti i poeti, i teologi, i legisti, i filosofi, gli istorici.'" More generally, on early modern classification, see F. S. Bodenheimer, "Towards the History of Zoology and Botany in the XVIth Century," in *La sciènce au seizième siècle. Colloque de Royaumont 1957* (Paris: Hermann, 1960), 285–296; Michel Foucault, *The Order of Things. An Archaeology of the Human Sciences* (New York: Vintage Books, 1970); David Knight, *Ordering the World. A History of Classifying Man* (London: Burnett Books, 1981), esp. chaps. 2 and 3; Scott Atran, *Cognitive Foundations of Natural History. Towards an*

Anthropology of Science (Cambridge and Paris: Cambridge University Press, 1990); Brian W. Ogilvie, *Observation and Experience in Early Modern Natural History* (Ph.D. diss., University of Chicago, 1997), esp. 337–343. My thanks to David Freedberg for allowing me to read his unpublished lecture, "Naming the Visible: Art and Natural History in the Circle of Galileo" (Munich, 1991).

4. See references cited in previous note and Agnes Arber, *Herbals, Their Origin and Evolution. A Chapter in the History of Botany (1470–1670)* (Cambridge: Cambridge University Press, 1986; 1st ed. 1912); Allen J. Grieco, "The Social Politics of Pre-Linnaean Botanical Classification," *I Tatti Studies* 4 (1991): 131–149, esp. 139ff.

5. As quoted by Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150-1750* (Cambridge: MIT Press, 1998), 154; see also Findlen, *Possessing Nature*, 17–31.

6. Findlen, *Possessing Nature*, 24; the visitor was Pietro Andrea Mattioli (1501–78), one of the most famous Renaissance doctors and botanical authors.

7. Ibid.

8. Ibid., passim.

9. See Giuseppe Olmi, "Osservazione della natura e raffigurazione in Ulisse Aldrovandi (1522–1605)," *Annali dell'Istituto storico germanico italiano in Trento* 3 (1977), 105–181; Olmi, *Inventario del mondo, passim*; Claudia Swan, "*Ad vivum, naer het leven*, from the Life: Considerations on a Mode of Representation," *Word and Image* 11 (October–December 1995): 353–372.

10. Blowfish is the common name for the porcupine fish, which is of the order *Tetraodontiformes*, and is most visibly characterized by spiny or plate-form scales. The stomach of two families of this order—*Diodontidae* (porcupine fish) among them—is highly modified such that it can inflate to enormous sizes; hence "blowfish." Inflation is caused by ingestion of water into a ventral diverticulum of the stomach when the fish is frightened or annoyed; deflation occurs when the fish expels the water. Inflation by air can also occur, when the fish is removed from the water or on death. The bodies of all porcupine fish are covered with sharp spines, which may become erect when the fish inflates. They generally have two fused teeth. Joseph S. Nelson, *Fishes of the World* (New York: J. Wiley, 1984), 379–386. Blowfish are native to the Pacific and Indian Oceans.

11. Examples of engravings showing the blowfish hanging from the ceiling of a collection include "The Museum of Francesco Calzolari" by Hieronymus Viscardus after Io. Bapt. Bertonus, in Benedictus Cerutus and Andrea Chiocco, *Musaeum Franc. Calceolari* (Verona: Apud Angelum Tamum, 1622); anonymous engraver, "The Museum of Ferdinando Cospi," in L. Legati, *Museo Cospiano* . . . (Bologna: Giacomo Monti, 1677). These prints are frequently reproduced in studies of cabinets of curiosities; see, for example, Ellinoor Bergvelt et al., *Verzamelen. Van Rariteitenkabinet tot Kunstmuseum* (Heerlen: Open Universiteit, 1993), figs. 64, 76, and 82.

12. "Zee eeghel/ dese vis is van omber wit en swart ijser graeu achtich/ van den rugghen neerewert al lichter tot den buijck/ die is wit nae de staert is hij noch bruijnder hij al gestippelt/ met keulse aerden de penne sijn geelenoocker achtich licht graeu/ de vinne sij omber en keulse aerdeachtich teghen tlijf geleoocker/ en wit wat root oock wat [illegible mark] blaeu achtich gekolleureert/ ende oock met keulse aerden gestippelt omden muijl/ wat omber achtiger gecollereert." Rijksmuseum, Amsterdam, inv. no. A3971 (149 x 197 mm, pen and brown ink on gray-brown paper). I. Q. van Regteren Altena, *Jacques de Gheyn. Three Generations*, 3 vols. (The Hague: M. Nijhoff, 1983), vol. 2, cat. no. 896, pl. 370; see also vol. 2: 119. Cf. K. G. Boon, *Netherlandish Drawings of the Fifteenth and Sixteenth Centuries. Catalogue of the Dutch and Flemish Drawings in the Rijksmuseum*, 2 vols. (The Hague: Govt. Pub. Office, 1978), cat. no. 242; and *Jacques de Gheyn II. Drawings*, exh. cat. (Rotterdam and Washington: Museum Boymans-van Beuningen, 1986), cat. no. 83: *Two Studies of a Porcupine Fish* (*Diodon hystrix*).

13. Jan Piet Filedt Kok and Marjolein Leesberg, The New Hollstein. *Dutch and Flemish Etchings, Engravings and Woodcuts, ca. 1450–1700* (*Jacques de Gheyn*), 2 vols. (Rotterdam: Sound and Vision, 2000), no. 213. On de Gheyn in Leiden, see Florence Hopper, "Clusius' World: The Meeting of Science and Art," in *The Authentic Garden. A Symposium on Gardens,* ed. Leslie Tjon Sie Fat and Erik de Jong (Leiden: Clusius Stichting, 1991), 13–36; Claudia Swan, *Jacques de Gheyn II and the Representation of the Natural World in the Netherlands ca. 1600* (Ph.D. diss., Columbia University, 1997).

14. See, *inter alia*, *Leidse Universiteit 400. Stichting en eerste bloei 1575–ca. 1650*, exh. cat. (Amsterdam: Rijksmuseum, 1975); Swan, *Jacques de Gheyn II*, chapter 5, "*'t Onderwijs der cruyden*: The Leiden University *Hortus* 1587–1600." The practice of teaching *materia medica* from the garden became widespread throughout Europe at this time; see Karen Meier Reeds, *Botany in Medieval and Renaissance Universities* (New York and London: Garland, 1981), passim.

15. For the inventories of the collection of *naturalia*, see *Leidse universiteit 400*, cat. nos. D24–26; Erik de Jong, *Natuur en Kunst. Nederlandse tuin- en landschapsarchitectuur 1650-1740* (Amsterdam: Thoth, 1993), "*Hortus Sanitatis*. De hortus botanicus en de hortus medicus als wetenschappelijke tuin," 190–234, esp. 202ff. In an appendix de Jong provides transcriptions of the two most important inventories of the collection housed in the *ambulacrum* (1617 and 1659) and cross-references them to Carolus Clusius, *Exoticorvm libri decem: Quibus Animalium, Plantarum, Aromatum, aliorumque peregrinorum Fructuum historiae describuntur* . . . (Leiden: Ex Officinâ Plantinianâ Raphelengii, 1605) and to a copy hereof that Clusius revised by hand, presently in the Leiden Universiteitsbibliotheek (UB nr. 755 A3). A version of this essay by de Jong was previously published as "Nature and Art. The Leiden Hortus as 'Musaeum'," in Tjon Sie Fat and de Jong, *The Authentic Garden*, 37–60. A very early source, to the best of my knowledge never cited, is the catalog by P. Pauw of the Leiden garden; see below, note 38.

16. Hollstein, vol. 29 (1984), Swanenburg(h), H. 32.

17. See above, note 15; the relevant chapters are Clusius, *Exoticorum* 21–24: 137–140.

18. Cf. the passage from *The Tempest* in which Trinculo exclaims, on finding Caliban: "What have we here? a man or a fish? dead or alive? A fish: he smells like a fish; a very ancient and fish-like smell; a kind of, not of the newest, Poor-John. A strange fish! Were I in England now, as once I was, and had but this fish painted, not a holiday fool there but would give a piece of silver: there would this monster make a man: when they will not give a doit to relieve a lame beggar, they will lay out ten to see a dead Indian (II.ii)." That fish and other sea creatures were put on public display in Leiden and Amsterdam is amply recorded in Clusius's *Exoticorum*.

19. See esp. Atran, *Cognitive Foundations of Natural History*; Ogilvie, *Observation and Experience*, 337–343.

20. Clusius writes that the *Histrix piscis* and the *Orbis spinosus* were available to him in a "museum" of a merchant in Amsterdam; see Clusius, *Exoticorum*, 137–138. The third kind he describes, the *Orbis muricatus*, he saw in Guillaume Rondelet's "museum" in Montpellier (139). Cf. (written of the *Orbis spinosus*) "Exenteratus autem erat hic piscis, quemadmodum & alij ejusdem generis, quos istîc variœ magnitudinis apud diversos mercatores videbam: satis enim diligentes sunt in ea urbe rerum exoticarum conquisitores, quas à nautis ex sua navigatione reducibis redimere solent" (139).

21. Clusius cites book 25 of Guillaume Rondelet, *L'histoire entière des poissons* . . . (Lyon: Bonhomme, 1558); Clusius, *Exoticorum*, 139.

22. These are the *Histrix piscis* (Clusius compares the specimen he describes and illustrates to the fish in Plateau's drawing) and the *Orbis muricatus alter*; see Clusius, *Exoticorum*, 138, 140. Plateau is also mentioned in Carolus Clusius, *Rariorum Plantarum Historia* (Antwerp: Ex. Off. Plantiniana, apud Ioannem Moretum, 1601), passim.

23. Namely, a drawing of the *Orbis muricatus*; Clusius, *Exoticorum*, 139. Porret is cited throughout the *Exoticorum*; see F. W. T. Hunger, *Charles de l'Escluse (Carolus Clusius) Nederlandsch Kruidkundige 1526-1609*, 2 vols. (The Hague: Nijhoff, 1927; 1943), Vol. 1: 268.

24. The woodcut of the *Orbis spinosus* is, Clusius explains, based on a drawing that was made in order for him to compare this specimen with the *Histrix piscis*; images of the *Orbis spinosus* and the *Histrix piscis* face each other head-on across the binding of the volume. "Ut autem faciliùs utriusque differentia observari possit, illum, permittente Mercatore, idem Volcardus in meam gratiam delineabat, ego verò in adposita tabella deinde exprimi curabam" (*Exoticorum*, 138).

25. Clusius, *Exoticorum*, 138.

26. Ibid. "De internis partibus nihil pronunciare queo, quandoquidem à recens capto fuerant exemptœ & abjectœ, & corium dumtaxat à nautis funiculorum fragmentis suffarcinatum, ut commodiùs resiccarent & conservarent, mihi fuit conspectum."

27. "In quo mari captus esset hic piscis, nemo certi quidpiam pronunciare poterat," he writes of the *Orbis muricatus*; Clusius, *Exoticorum*, 140. On p. 137, however, he identifies the *Histrix piscis* as having been captured in the "American Ocean."

28. "Horum trium subsequentium Orbium historiam adeò exactè describere non licebit, ut superiorum [*Orbis muricatus*], quia ipsos pisces videre mihi non contigit, sed eorum icones coloribus expressas dumtaxat accipiebam à Iacobo Plateau, nullis adscriptis notis, è quibus magnitudinis corporis & ejus partium conjecturam facere possem: post aliquot tamen menses à me admonitus, hujus & sequentis mensuram, longitudinem & ambitum designantem, mittebat" (Clusius, *Exoticorum*, 140).

29. Foucault, *The Order of Things*, 137.

30. More generally, on the representation of variable qualities of plants, see also David Freedberg, "The Failure of Colour," *Sight & Insight. Essays on Art and Culture in Honour of E.H. Gombrich at 85* (London: Phaidon Press, 1994), 245–262.

31. Clusius, *Rariorum*, lib. 2: 147; as trans. by W. Van Dijk, *A Treatise on Tulips by Carolus Clusius of Arras* (Haarlem: Enschedé en Zonen, 1951), 50.

32. Clusius, *Rariorum*, lib. 2: 148; Van Dijk, *A Treatise on Tulips*, 52. The letter from Johannes de Jonghe, dated 14 May 1596 and received by Clusius in Leiden on 2 June, is in the Leiden University Library (Cod. Vulc. 101); it and seven others written to Clusius by residents of Middelburg were transcribed and published by F. W. T. Hunger, "Acht Brieven van Middelburgers aan Carolus Clusius," *Zeeuwsch Genootschap der Wetenschappen* (1925), 110–133; for the letter from de Jonghe, see 111–113. See also Laurens J. Bol, *The Bosschaert Dynasty. Painters of flowers and fruit* (Leigh-on-Sea: F. Lewis, 1980), 17–18, who suggests that the Middelburg flower painter Ambrosius Bosschaert may have painted this (lost) drawing and another drawing sent to Clusius by another Middelburg resident in 1597.

33. See F. de Nave et al., *Botany in the Low Countries (End of the 15th Century–ca. 1650)*, exh. cat. (Antwerp: Plantin Moretus Museum, 1993); Swan, "*Ad vivum, naer het leven*."

34. Foucault, *The Order of Things*, 132.

35. C. Swan, "*Ad vivum, naer het leven*."

36. By grid I mean a rectangular diagram, divided into small rectangles. On dichotomized and bracketed outlines, and on class logic, see W. J. Ong, *Ramus, Method, and the Decay of Dialogue. From the Art of Discourse to the Art of Reason* (Cambridge, Mass.: Harvard University Press, 1958), esp. chaps. 8 and 9; cf. *idem*, "From Allegory to Diagram in the Renaissance Mind: A Study in the Significance of the Allegorical Tableau," *Journal of Aesthetics and Art Criticism* 17 (June 1959): 423–440.

37. *Kruydtboeck oft Beschrijuinghe Van allerleye Ghewassen, Kruyderen, Hesteren, ende Gheboomten* (Antwerp: Christoffel Plantijn, 1581): "Vande Succedanea, dat is te seggen/ van drooghen oft cruyden die by ghebreke d'een voor d'ander ghebruyckt worden . . ." (15 pp).

On p. 1, Lobelius complains that prior publications on medicinal simples were "sonder eenige ordeninghe/ onderscheydt oft verstant" ("lacking all order, distinctions, and judgment"). "Vande Succedanea" and its tables were reprinted in *Den Leytsman ende Onderwijser der Medicijnen, oft ordenlijcke uytdeylinghe ende Bereydingh-boeck vande Medicamenten*, eds. Pieter van Coudenberg and Matthias Lobelius (Amsterdam: Hendrick Laurentsz., 1614).

38. See Peter Pauw, *Hortvs Pvblicvs Academiæ Lvgdvno-Batavæ. Eivs Ichnographia, Descriptio, Vsus. Addito quas habet stirpium numero, & nominibus* (Leiden: Ex Officina Plantiniana apud Christopher Raphelengius, 1601) fol. 4r. Actual evidence of what was planted—and grew—in the garden in 1601, 1602, 1604, and later years is provided by the copies of Pauw's catalog, which were filled in by Pauw himself and others for presentation to the trustees of the university; several of these are in the National Herbarium of the Netherlands, Leiden.

39. Pauw, *Hortvs Pvblicvs*.

40. There are a total of 176 pages in the catalog. In 1603, the catalog was printed in Leiden by Ioannes Patus (Ex. Officinâ Ioannis Patii, Academ. Lugduno-Bat. Typographi), in revised edition; the page size is smaller, and there are minor changes to the text. That de Gheyn's engraving of the garden was intended for inclusion in the book when it was first published is clear from the marginal note in the 1601 edition that reads, "ad ea quæ sequuntur, inspicienda erit Horti ichnographia, inserta pagina" (fol. 7v.); this marginal note does not occur in the 1603 edition.

41. See F. W. T. Hunger, "Bernardus Paludanus (Berent ten Broecke) 1550–1633. Zijn verzamelingen en zijn werk," in *Itinerario voyage ofte schipvaert van Jan Huygen van Linschoten 1579–1592 IIIe deel,* ed. C.P. Burger and F. W. T. Hunger (The Hague: M. Nijhoff, 1934), 249–268; H.D. Schepelern, "Naturalienkabinett oder Kunstkammer. Der Sammler Bernhard Paludanus und sein Katalogmanusckript in der Königlichen Bibliothek in Kopenhagen," *Nordelbingen. Beiträge zur Kunst- und Kulturgeschichte* 50 (1981): 157–182; E. Bergvelt and R. Kistemaker, eds., *De wereld binnen handbereik. Nederlandse kunst- en rariteitenverzamelingen, 1585-1735* (Zwolle/Amsterdam: Waanders Uitgevers/Amsterdams Historisch Museum, 1992); Roelof van Gelder, "Paradijsvogels in Enkhuizen. De relatie tussen Van Linschoten en Bernardus Paludanus," in Roelof van Gelder, Jan Parmentier, and Vibeke Roeper, *Souffrir pour Parvenir. De wereld van Jan Huygen van Linschoten* (Haarlem: Uitgeverij Arcadia, 1998), 30–50, esp. 35–41.

42. *Index Rervm Omnivm Natvralivm, a Bernhardo Palvdano, Medicinæ Doctore, et Civitatis Enckhvsensis Physico experientissimo, collectarum*, in *Warhaffte Beschreibung Zweyer Raisen* (Tübingen: In der Cellischen Truckerey, 1603), 46ff. (24 unnumbered pages); see Van Gelder, "Paradijsvogels in Enkhuizen," 36–38.

43. The classic study is Hans Fischer, *Conrad Gessner. Leben und Werk* (Zurich: Kommissionsverlag Leemann, 1966); cf. Hans Fischer, G. Petit, J. Staedtke et al., *Conrad Gessner 1516–1565. Universalgelehrter, Naturforscher, Arzt* (Zurich: Orell Fussli, 1967). See also the facsimile edition of the watercolors by Gessner of plants, which he died before publishing; H. Zoller and M. Steinmann, *Conradi Gesneri Historia plantarum. Gesamtausgabe*, 2 vols. (Zurich: Urs Graf Verlag, 1987–1991).

44. Caspar Wolf, *De Stirpivm Collectione Tabulæ Tvm Generales, Tvm per Dvodecim Menses, cum Germanicis nominibus, & alijs hactenus à nemine traditis, olim per Conradum Gesnerum conscriptæ ac æditæ* . . . (Zurich: Ch. Froschauer, 1587); Universiteitsbibliotheek Amsterdam, 613 H 27.

45. "Conradi Gesneri de Partibvs et Differentiis Plantarvm Physica Syn-nopsis . . . in tabulas methodicè digesta," fols. 1r.–40v.; a header runs throughout these folios, identifying them as "Tabulae stirpivm in genere."

46. "De Collectione stirpivm in genere," fols. 41r.–55v; the page header for this section is "De Collectione in genere."

47. "Tabvla Stirpium prima, alphabetice envmerans . . . ," fols. 56r.–116r.

48. "Tabvla secunda stirpivm nomina Latina et Germanica continens, quæ singulis mensibus aut florent aut fructum maturant . . . ," fols. 116v.–147v.

49. "Tabvlae istæ non pharmacopolis tantùm, tyronibus præsertim & minus exercitatis, vtiles sunt futuræ, sed omnibus stirpium notitiæ studiosis. Qui cum singulis ferè mensibus vernis, æstiuis & autumnalibus, partim cognitionis, partim animum remittendi & corpus exercendi gratia, rusticatum exire soleant, occasionem ex hisce tabulis capient, quœnam eis plantœ potissimum quærendæ aut sperandæ sint."

50. The literature is vast. See especially Beatrijs Brenninkmeyer-de Rooij, *Roots of Seventeenth-Century Flower Painting. Miniatures, Plant Books, Paintings*, ed. R. E. O. Ekkart; trans. Ruth Koenig (Leiden: Primavera Press, 1996); Paul Taylor, *Dutch Flower Painting 1600–1720* (New Haven, Conn.: Yale University Press, 1995); Sam Segal, *Flowers and Nature. Netherlandish Flower Painting of Four Centuries* (The Hague: Government Publishing Office, 1990); Norbert Schneider, "Vom Klostergarten zur Tulpenmanie. Hinweise zur materiellen Vorgeschichte des Blumenstillebens," in G. Langemeyer and H. A. Peters, *Stilleben in Europa* (Münster: Landschaftsverband Westfallen-Lippe, 1979), 294–312.

51. Bol, *The Bosschaert Dynasty*, 46; see also, on this phenomenon in France, Antoine Schnapper, *Le géant, la licorne, et la tulipe. Collections et collectionneurs dans la France du XVIIe siècle. I - Histoire et histoire naturelle* (Paris: Flammarion, 1985), 354 and 358–360, where Schnapper speaks of "les 'portraits' de fleurs ou de fruits commandés par un amateur désireux de péerenniser le souvenir des pièces les plus précieuses, mais essentiellement périssables, de sa collection."

52. For a recent example of such an approach, see A. Chong, W. Kloek et al., *Still-Life Paintings from the Netherlands 1550–1720*, exh. cat., trans. R. Koenig et al. (Zwolle: Waanders Publishers, 1999), passim. For another counterproposal, the focus of which is on the social and economic formations that inform still life paintings, see E. A. Honig, "Making Sense of Things: On the Motives of Dutch Still Life," *Res* 34 (autumn 1998), 166–183.

53. *De Constantia* was first published in Leiden in 1584, and was reprinted in a variety of European languages (Dutch, French, German, English, Italian, Spanish, and Polish) in as many as eighty editions throughout the seventeenth century. The first Dutch translation, by Jan Moretus, was published as *Twee Boecken vande Standvasticheyt*, Leiden, 1584 (*Over standvastigheid bij algemene rampspoed*, trans. and annotated P. H. Schrijvers [Baarn: Amboboeken, 1983]). The Erasmian model of the humanist's garden is set out most famously in the colloquy *The Godly Feast* (*Convivium religiosum*, 1522); trans. and ed. C. R. Thompson, *The Colloquies of Erasmus* (Chicago: University of Chicago Press, 1965), 46–78, esp. 46–47 and 51–52.

54. In 1578, at the age of thirty, Lipsius was made a professor of history and law at Leiden University; he and his wife lived at Leiden for thirteen years, until 1591, at which time he returned to Flanders (Louvain) and to Catholicism, from which he had converted to Lutheranism when he took a post at Jena in 1572.

55. Mark Morford, "The Stoic Garden," *Journal of Garden History* 7 (1987): 151–175, esp. 165–167.

56. Trans. mine, from German (1st German ed., 1601); bk. 2, cap. 2.

"Strange" Ideas and "English" Knowledge

Natural Science Exchange in Elizabethan London

DEBORAH E. HARKNESS

During the reign of Elizabeth I, a public well—the traditional neighborhood locus for gossip, news, and information—stood at the crossroads of Bishop's Gate and Threadneedle Streets in London, near the Royal Exchange. Given the colorful occupations of many area residents, and its proximity to Bedlem hospital, one can but imagine that the quality of gossip there was high. Within a few square blocks lived an extraordinary assortment of characters, many of whom made hands-on investigations into the marvelous workings of nature. When John Dee was in London he lived right in the thick of this neighborhood, along with his mathematics pupil Sir William Pickering, and Sir Thomas Gresham, builder of the Royal Exchange. Several members of the Royal College of Physicians also made Bishop's Gate their home, such as the botanically inclined Peter Turner, and the Venetian-born Dr. Caesar Aldemare, who had been trained at the famous medical school in Padua. Aldemare was one of the many foreigners in Bishop's Gate, and the voices of Bedlem would have had to be very loud to drown out the cacophony of tongues generated by the Flemish, French, Dutch, German, Italian, and Spanish residents. These "strangers" included many natural science practitioners: instrument makers, surgeons, midwives, alchemists, and distillers. Neither a humanistically informed natural philosophy, nor a university-taught Galenic medicine, nor a hands-on skill in technology is sufficient to describe the range of interests and activities within the metropolis of London. And so I fall back on "science," which was used commonly in the period to describe those things that required knowledge, but not exclusively theoretical or exclusively practical knowledge. As John Securis explained in his *Detection and querimonie of the daily enormities and abuses co[m]mited in physick*, "science is an habite, . . . [a] ready, prompt and bent disposition to do any thynge, confirmed and gotten by long study, exercise, and use." Securis's emphasis on

study, exercise, and use defines how most Elizabethan science practitioners interested in the natural world occupied their time and made their living.[1]

To locate these English and alien practitioners—many of whom did not publish—we must turn to the minutiae that historians of science wade through when they conduct their research: the tortured book prefaces that introduce nearly every scientific work of the period, the roll books of the Barber-Surgeons and College of Physicians, the annals of Oxford and Cambridge Universities, and the diaries of those few men like Dee who left written remains of their practices. But we must also look beyond these sources to the minutiae that historians of science seldom consult: parish registers, the addresses on the back of state papers, petitions for patents and monopolies addressed to the queen, probate cases, and the censuses that were intended to account for the names and occupations of every Stranger living and working in London.[2] Together, these documents can provide historians of science with a richer and more textured sense of natural science practitioners in Elizabethan London—a mapping of who they were, whence they came, how they were educated, and where and with whom they lived and practiced.

While this mapping process would, in and of itself, constitute valuable factual information for historians of early modern science, it also sheds light on the daily practice, the economic imperatives, and even the contemporary conception of science in the period. The evidence also provides an intriguing glimpse into the exchange of ideas and the importance of intellectual community in Elizabethan London. We learn from the mapping process that distinct neighborhoods of science sprang up throughout the city, some housing mainly medical practitioners, one constituting the instrument-making center of London, and still others providing communities for chemical distillers, alchemists, compass makers, and gardeners. While we might think of science practitioners in Elizabethan London as a few scattered individuals, it is clear that one had only to walk down the street to St. Martin Ludgate to have a discussion about anatomy,[3] visit St. Antholin's parish to debate the significance of comets with John Dade and Richard Forster,[4] mingle with the gardeners of St. Giles Cripplegate to learn how to propagate olive trees,[5] or procure a novel remedy for sciatica from the Paracelsian apothecaries and innovative physicians and surgeons of St. Benet Paul's Wharf.[6]

Natural science neighborhoods and practitioners in London were not exclusively English, however, but were international in composition and outlook. It is thus important to recognize that there was no purely English natural science in the period, but only a natural science practiced in England by a variety of individuals both native and foreign, some university trained and others barely literate. As early as 1571, the official census of strangers indicated that the city of London was home to 4,850 non-native workers, who made up approximately 4.9 percent of the total population.[7] More than

75 percent of that number were from the Low Countries; the remainder included French, Italian, Spanish, Scottish, Portugese, Danish, Greek, and even Turkish men and women.[8] The numbers of Strangers in the city only increased during the remainder of the century, mostly because religious and political conflicts on the continent forced many people to seek protection in Protestant England.

A healthy proportion of these immigrants possessed skills that brought them to the attention of London citizens interested in the properties of nature. The 1571 census lists twelve Strange physicians, for example, only a few of whom were licensed to practice by the authorities. Sixteen men and women from Burgundy, Antwerp, and Amsterdam professed to being surgeons, while three apothecaries—one Italian, one from Flanders, and a woman from Holland—also worked in the English medical marketplace. Eight professional gardeners from other countries lived in the city in 1571, working both inside and outside the city gates in the garden plots of the wealthier citizens. In addition, many skilled Strangers engaged in trades that supported natural science—glassmakers who made alchemical vessels, potters who shaped apothecary jars, and clock-makers who could craft any number of mechanical marvels such as intricate clocks and astrolabes.

The presence of so many Strangers among London's natural science practitioners suggests that a wide-ranging intellectual atmosphere pervaded the streets and neighborhoods of the city. London provided a lucrative and vital environment for natural science practitioners, and the sheer number of practitioners who lived and worked in the City during the period was much higher than the number who were maintained at, or even circulated through, the royal court.[9] Yet the influx of "strange ideas" was bitterly resented by some because alien natural science practitioners drew clients away from citizens in the tight London market, and because their very unfamiliarity made them stylish to urban consumers.

English natural science practitioners complained frequently about the inroads their alien competitors were making into London commerce. One medical practitioner wrote of the "runners about called cutters for the stone," Strangers who

> have suche a great name at their first coming. But after . . . their work be tried and then the proof of them seen: the people for the moste parte are wery of them. . . . Such is the foolish fantasyes of our English nation that if he bee a Straunger: he shall have more favourers then an English man, though the English mans knowledge doo far passe the others. . . . "[10]

A physician charged that a few of London's popular medical practitioners were actually feigning alien behaviors in order to gain a clientele: "Some-

times, [popular physicians] fain themselves to be of some straunge countrey, and wyll counterfayte their language."[11]

English and alien practitioners competed with each other for economic survival by relying upon a variety of time-tested strategies to carve out a niche for themselves. Some resorted to advertising to draw potential clients to their doors, such as surgeon Edward Parke (fl. 1564–88), who in 1568 erected a sign outside his shop that described him inaccurately as "the skoller [scholar] of St. Thomas of Willyngforde." Parke was competing with three surgeons in the parish of St. Dunstan in the West, and though he undoubtedly knew that the Barber-Surgeons would demand he take down the sign, the opportunity to set himself apart from his commercial competition by claiming some education was too great to resist.[12] Other practitioners favored more theatrical demonstrations of their knowledge in the homes of clients or in the open, as did the surgeon John Smythe (fl. 1556–73) who was admonished by the Repertory Court of Aldermen in 1573 to "make open show" of his surgical skills "against his own house and dore and not elsewhere."[13]

Others settled in a neighborhood already reputed to offer the latest designs in compasses and other scientific instruments, chemical preparations, or surgical techniques, as did a host of foreign clock, instrument, and watch makers who flooded into the former ecclesiastical Liberty of the Blackfriars following in the footsteps of the well-known engraver, instrument maker, and medical empiric Thomas Gemini (fl. 1540–1562). Most of London's natural science neighborhoods were based, like the Blackfriars, on one or more parishes, and were anchored by a parish church where the English and some immigrant households worshipped. Though many of the Strangers attended their own Protestant churches—either the French, Dutch, or Italian congregations—all those residing in the parish at the time of death were recorded in the parish's register of births, marriages, and deaths. The size of London's parishes varied widely from the minute St. John the Evangelist not far from St. Paul's Cathedral to the suburban sprawl of St. Botolph Aldgate. Even the smallest—and some were less than one square acre—could house a surprisingly large number of residents by today's standards.[14]

Because of trade restrictions that were enforced by the City's guild and livery companies, many immigrants gravitated toward those areas in the city where corporate control was at its weakest, namely the former ecclesiastical Liberties, the suburbs, and the areas within the city walls just adjacent to the old gates. What these areas had in common was greater freedom, greater space, and a more equitable mix of English and Strangers than could often be found in the center of the City in neighborhoods that were largely controlled by the guilds and livery companies. There the organizations fostered their own sense of community that was based not on neighborhoods, but on

allegiance to the company, and thus acted as a counterweight to neighborhood associations.[15]

The masters of London's guilds and livery companies, who were charged with the task of regulating commercial behavior and restricting nonmembers from engaging in their trades, were keen to apprehend both Strangers and English citizens who impinged on their privileges. The Royal College of Physicians, for example, vigorously sought out the French medical practitioner Charles Cornet (fl. 1555–98), whom they described as "an Ignorant Fleming and a most shameless buffoon," after he put up bills of advertisement "on all the Corners of the City." The college punished Cornet by seizing "his feigned and unwholesome remedies" and throwing them into a bonfire in Westminster's public market.[16] Such efforts were a particular hardship to the alien practitioners, who were technically restricted from guild membership except in special circumstances: at the request of the queen or high-placed noble, for example, or if the alien practitioner met guild standards through an examination or demonstration. Those few Strangers who managed to become foreign members of the City's guilds and livery companies paid steeply for the privilege.

As a result, many Stranger practitioners resorted to higher governmental authorities, such as the City's Repertory Court of Aldermen and the queen, for permission to advertise their services and practice their natural sciences. Peter van Duran (fl. 1559–84), a brewer in St. Olave Southwark who was also known by his colorful nickname "Pickleherring," for example, satisfied the Aldermen that he "professethe ye knoledge & science of surgery," and he was given permission in 1563 to "sette up bylles upon posts in such p[ar]ts of the Cytye as to him shall seeme good to give the people knowledg of his said science."[17] The Dutch empiric Margaret Kemmex (fl. 1576–83), following persistent efforts of the Royal College of Physicians to close down her medical practice, successfully appealed to the queen and Sir Francis Walsingham for protection. In 1581, Walsingham found it necessary to remind the College that "it was her highness pleasure that the poore wooman should be permitted by you quietly to practise and mynister for the curing of diseases, and woundes, by the meanes of certaine simples."[18] Walsingham cited two reasons why Kemmex should be allowed to practice unmolested, one knowledge-based and one shaped by economic imperatives: "god hath given her an espetiall knowledge [of simples] to the benefit of the poorer sort," and also for "the better maintenaunce of her impotent husband and charge of family, who wholy depend un the exercise of her skill."[19] Unwilling to let Walsingham have the last word on such an important matter, the College responded on 22 December 1581 that Kemmex's "weaknes and insufficiency is suche as is rather to be pitied of all, then either envied of us or maintayned of others."[20]

Royal patents often became the vehicle for immigrants to secure the right to practice their skills despite guild and livery company restrictions, and for the queen to ensure that some English citizens were trained in the process. Patent petitions often contain evidence of heated intellectual debates between Strangers and English citizens during which expertise and knowledge were called into question. It was in the best interests of the crown, however, to arrange a collaborative détente. The responsibility for this kind of brokerage and peacemaking fell to Elizabeth's secretary of state, William Cecil. For decades Cecil vetted and supervised natural science projects like an early prototype of today's National Science Foundation, judging the merits of each proposal and, whenever possible, turning would-be competitors into scientific collaborators, as will be seen below. One factor always governed his decisions: the profit that the patent holders would be able to bring to the crown.

The spirit of commerce is vividly captured in many of the exchanges that took place between natural scientists, their clients, and the crown in Elizabethan London. Given London's competitive markets, we should not be surprised that natural science ideas and expertise, be they English or alien, had definite economic worth. Few doubted that some profit could be gained by more highly trained mathematicians who might keep your accounts in order, for example, or from a more fuel-efficient furnace, and most were prepared to invest money in far riskier schemes to transmute metals, mine for precious minerals, and construct water mills on London Bridge. Natural science practitioners thus competed in a commercial world in which ideas and materials were quickly transmuted into merchandise. This transformation was part of a general trend toward merchandising of which John Wheeler, in his *Treatise of Commerce* (1601), complained: "There is nothing . . . so ordinarie, and naturall unto men, as to contract, truck, merchandise, and traffike one with an other, so that it is almost impossible for three persons to converse together two houres, but they wil fal into talk of one bargaine or another." Commerce and exchange, Wheeler noted, were no longer the sole province of merchants, but preoccupied everyone, high and low: "The Prince with his subjects, the Maister with his servants, one friend and acquaintance with another . . . the Husband with his wife, [and] women with and among themselves." Wheeler regretted the emphasis on commodities that resulted when his world went mad for merchandising. "[A]ll the world choppeth and changeth, runneth & raveth after Marts, Markets and Merchandising, so that all thinges come into Commerce," Wheeler lamented, "[T]his man maketh merchandise of the workes of his owne handes, this man of another mans labour, one selleth words . . . [and] all that a man worketh with his hand or discourseth in his spirit is nothing els but merchandise."[21]

The ways in which natural science practitioners struggled for economic survival in this mercantile atmosphere provide us with important insights into the conditions of intellectual exchange and the dynamics of commercial competition in Elizabethan London. For some, as we will see in the examples below, economic survival could best be fostered through collaboration with Strangers that would blend their alien ideas and practices with English traditions. This was particularly true for practicing alchemists and engineers who preferred syncretism, in which the resulting ideas or products represented an innovative blend of English and non-English knowledge and practice. Other English and alien practitioners, especially clock makers and other instrument makers, preferred to work apart from each other in distinct neighborhoods. For medical practitioners who faced enormous competition, however, there was a blend of conflict and collaboration that could bitterly divide some practitioners while bringing others more closely together in the face of their detractors. When taken as a whole, these examples are evidence of the complicated ways in which natural science practitioners faced challenges in an urban, mercantile environment.

PARACELSIAN THERAPEUTICS AND THE MEDICAL MARKET: COMPETITION, COLLABORATION, AND CONFLICT

Because medical practitioners were by far the largest group of natural science practitioners within the Elizabethan City, encompassing physicians, empirics, surgeons, and barber surgeons, midwives, "cutters for the stone," occulists, dentists, midwives, and nurses, understanding the challenges that faced these practitioners and the negotiations that took place between alien and English ideas represents an important contribution to our understanding of urban-based natural science practice. In addition, medicine often provided the means by which English and immigrant practitioners could engage in other, less lucrative branches of natural science such as natural history, astrology, and alchemy. It is all the more important, therefore, that we understand the tensions between English and Strange practitioners, how they were resolved, and the conditions under which intellectual exchange could take place.

Medical practitioners represented a wide array of educational backgrounds, from illiterate empirics who learned most of their skills from demonstration and hands-on experience, to university-trained members of the Royal College of Physicians. Despite these differences, there were often strong links among what might seem on the surface to be entirely different types of practitioners. The evidence suggests that physicians, surgeons, and apothecaries did indeed form strong friendships through shared patients,

remedies, and neighborhood ties. The close working relationships that could occur between physicians and apothecaries can be seen in the medical and alchemical papers of the apothecary Edward Barlow (fl. 1581–94), which mention which physicians he provided with drugs and medicines on a regular basis, including Strangers Johann Vulpe (fl. 1581–89), Hector Nonez (fl. 1553–92), and John Shoring (fl. 1592/3) and Englishmen Thomas Penny (fl. 1569–89), Richard Forster (c. 1545–16), and Walter Baylie (fl. 1580–91/92). Barlow's notes also indicate that English and alien physicians shared cases, as did Christopher Atkinson and Hector Nonez.[22] The relationships that Barlow forged with members of the Royal College of Physicians are all the more interesting because he was reprimanded in 1581 for practicing medicine without the organization's consent.[23]

It was not uncommon for husband-and-wife partnerships to exist among the surgical practitioners in Elizabethan London, or for surgeons to marry midwives and establish a joint practice. Such is the case with surgeons Hugh and Ann Vellam, immigrants who operated a joint practice in the late 1560s which continued to be active after Hugh's death in 1568.[24] William Baxter, a member of the Barber-Surgeons Company, was married to Emma Philipps (fl. 1571–1603), whose brother, Edward Philipps, was an apothecary. Emma Philipps was a medical empiric, and drew the ire of the Royal College of Physicians, which described her as "an ignorant and bold woman" and committed her to prison.[25] Guillaume Alaertes, a Stranger surgeon, was married to a midwife, Lieven Alaertes, who was described, much like Emma Baxter, as "an ignorant old woman" by the Royal College of Physicians.[26]

Given such a variety of backgrounds and expertise it is not surprising that there was both fruitful collaboration and tense competition amongst medical practitioners. Though many English practitioners resented the success of the Strangers, for others the presence of alien ideas presented an opportunity to share new ideas, books, and techniques. Surgeon George Baker (fl. 1577–1607), for example, praised the diverse backgrounds and expertise of London apothecaries, and complimented the work of "Maister Kemech an English man," "mayster Geffray, a French man," and John Hester, whom he called "a paynfull traveyler in those matters, as I by proofe have seene."[27] But Baker did not approve of all alien ideas: in his book on the preparation of *oleum magistrale* he scathingly criticized the London followers of Paracelsus for putting their patients' health at risk.[28]

John Hall's (fl. 1565) translation of Lanfrank's *Chirurgia parva* (1565) recounts a fascinating tale of exchange which took place during his walk along Bucklersbury, the London street famous for its grocery, spice, and drug stores.[29] There he met a "woman [who] came to sell hearbes, to the Apothecaryes." She offered the apothecaries maidenhair, but Hall was

aghast when the herb gatherer produced "Nothinge agreeinge with that whiche she named: But only it had rounde leaves, standinge in good order on eche syde [of] the stalke, as maiden heare hathe." Hall took a sample of the plant, in case he "might meete with anye, that knew it, and so to attaine the name therof." Within an hour Hall was encouraged to consult with an alien physician by his friend "master Gale Chirurgien of London" who lived nearby on Lime Street in the parish of St. Dionysius Backchurch.

Lime Street was full of foregin-born practitioners with excellent intellectual credentials, including the physician and botanist Matthew L'Obel.[30] While we cannot be sure that Gale and Hall consulted L'Obel, it is certainly possible. Whoever the physician was, he exchanged "divers communications" before meeting with Gale and Hall to view the troublesome specimen. Hall and the alien physician soon parted company after the Stranger "sayde it made no matter to be so precise in the knowledge of herbes." This single anecdote is laced through with all sorts of exchanges: between the herb woman and the apothecaries, between the apothecaries and Hall, between Hall and his friend Thomas Gale, and between Gale, Hall, and the immigrant population of physicians and surgeons. In this case, the potential collaboration between the English surgeon and alien physician did not come to fruition because the physician's "strange ideas" were incompatible with the English surgeon's beliefs and practices.

It was Paracelsus and his remedies, however, that most polarized the English and alien medical practitioners. One of the most notorious and well-documented showdowns between Paracelsian advocates and opponents involved Valentine Russwurin of Schmalkald.[31] Self-described as a "Medicus spagirirus opt[halamistus],[32] Russwurin was made denizen by Elizabeth in 1574 at the same time that he was practicing his Paracelsian remedies on the London population.[33] Russwurin's London career became problematic when he took up the cure of Helen Currance, a musician's wife, on 3 April 1574. In the presence of witnesses, Russwurin "did attempt with his instruments to have taken out of her bladder a stone." The witnesses later alleged that "finding none there, privily he tooke a stone out of the pocket of his hose . . . conveyed it into a spunge . . . [and] forst it in Pudendo."[34] When this procedure failed to relieve her discomfort, Russwurin sent her a powder that made it impossible for her to urinate. Uncomfortable side effects from the powder included blisters in her mouth, nose, face, and "inward parts of her bodie," which rendered her unable to eat.

Russwurin continued to treat patients for bladder stones, and branched out to treat various illnesses of the eye, including cataracts. Most egregiously affected was Mr. Castleton, a scholar of Cambridge, who still retained some vision when he contracted for a cure with Russwurin. Shortly after their agreement, Valentine "by his rustical dealings, put out his eyes cleane, and so

deprived him of all his sight." Castleton had Russwurin arrested at the Royal Exchange, "wher he did display his banners and wares . . . being in the middest of his pontificalibus."[35]

Finally the matter was brought to the Court of Aldermen on 22 April 1574 who heard "certen complants and objections" from Russwurin's patients as well as surgeons George Baker and William Clowes.[36] According to Clowes, Russwurin left behind him a very long list of dead patients—twenty-three in all—from all walks of life including Master Mace, a grocer, the servant of goldsmith Master Dummers, and two Strangers.[37] The court put together a committee of two aldermen and two physicians, with instructions that they should call upon the expertise "of the Discretist and best skylled surgeons of this cytie" to judge Russwurin's "knowledge & skill in s[ur]gerye."[38] Safely incarcerated in the Newgate Prison, Russwurin was examined by a new, largely English committee on 10 May 1574.[39]

No account survives of Russwurin's trial, and so we must rely on one of his fiercest critics, William Clowes, for our insights into what transpired. According to Clowes, Russwurin had only one defender: a "proud bragger . . . of the foresaide Adders broode . . . a man of little skill, and lesse honestie . . . [who] practiseth Chirurgerie, without all order or aucthoritie." An unascribed note in a sixteenth-century hand in the British Library's copy of Clowes's work states that this was "John Hester Alchymist at Paul's Wharf," who was a known supporter of Paracelsian ideas.[40] Hester claimed that "Velentine Rasworme was a wise Alchymist, " and that Clowes and Russwurin's other opponents were "ignoraunt fooles and asses."[41] Clowes felt unable to judge Russwurin's alchemical skill, but did report that "I doe know wise Alchimistes, of mine opinion, that accounts him in deede, an arch coosener, and loper, and Quacksalver."[42]

According to a treatise on the chemical analysis of urines and other opthamalgic matters addressed to William Cecil, Russwurin may well have impressed John Hester as a "wise Alchymist" because of his knowledge and incorporation of Paracelsian ideas into his medical practices. Russwurin chemically analyzed Cecil's urine, weighing it carefully to find that it was "eyght ounces and a lytle more, wherein it hath no difference from a sound man his water at all."[43] He also discussed the problems Cecil's mother was having with her cataracts, focusing on their hard "Tartar."[44] These preoccupations put Russwurin's practices well within the concerns of Paracelsian therapeutics and would have resonated with anyone who had read works by the author.[45]

While much more needs to be done to tease out the full implications of the Russwurin case for a better understanding of the influence of Paracelsian medicine in London, it is clear that such an analysis must take into account the connections that were made between commercial success and alien ideas within the city.[46] For there was more at stake than just theoretical

concerns when an English practitioner decried a Paracelsian cure—economic and nationalistic matters were of at least equal importance. Eleven medical treatises making reference to Paracelsus were printed in the six years following the Russwurin case, marking a definite spike compared to print trends prior to 1574. This evidence suggests that Russwurin, no matter his fate at the hands of the English authorities, had an effect on the commercial exchange of ideas in Elizabethan London.[47] While conflict might overshadow collaboration and influence when viewed from the distance of nearly five hundred years, the Russwurin case reminds us how complicated intellectual exchange could be in the early modern period.

MECHANICAL MARVELS: STRANGE IDEAS AND ROYAL PATENTS

While medicine was a feature of life for nearly all residents in Elizabethan London, the city was also a feast for the eyes of anyone interested in machines, engineering, and visual displays of technological prowess. Those interested in mechanical marvels could visit the windmills and glasshouses in St. Giles Cripplegate just northwest of the city walls, or feel the heat of the brick kilns and gun foundry in St. Botolph Aldgate to the northeast of the city center. Smaller-scale industries also thrived within London's walls, including clock- and watchmakers, mathematical instrument makers, and a variety of smiths working on copper and iron. Public interest in viewing such marvels is evident in the Court of Aldermen's decision on 17 October 1588 to exhibit in the Guildhall an "artificial motion" devised by Henrick Johnson from Utrecht in the Netherlands. The Guildhall was the symbolic center of the City's civic power and judicial prerogatives, and it is striking that the Aldermen permitted a Stranger to display his invention there. The Aldermen did so at the request of Sir Thomas Heneage, Queen Elizabeth I's chamberlain of the household, with the stipulation that the display be for "such inhabitants of this city [and] others who shall be willing to see the same."[48]

Instruments, artifical motions, clocks, and watches were much in vogue in the period, their importance raised to new prominence through England's naval expeditions and the influx of European-style watches and clocks that accompanied the immigrants when they entered England. While the desire to possess such items did not always indicate the purchaser's interest in the finer points of natural science, the expense and stylishness of mechanical marvels indicate their cultural currency. William Bourne, a well-known author of navigational and mathematical texts, explained that prices for some instruments put them out of reach for those natural science practitioners who could make most use of them, such as the "Mariners heere in Englande for that the charges is so muche in the making of them." Bourne was

especially thinking of equinoctial dials, which indicated "the houre of the day, & to shew the true shadowe of the Moone," which were not "used by any English Master or Pylot, but only by one man, which person had not it for the proper use therof, but rather had it, to say that he had suche an instrument as no English man had the like, & to bragge that he had such an instrument that he could do great feates therewith in the going of long viages."[49]

The relative rarity of instruments and their high asking price provided skilled English and non-English technicians with the economic incentive to produce more and more of the highly desired watches, clocks, and mathematical instruments. Yet unlike the medical practitioners—for whom there is so much evidence of collaboration and conflict—alien and English instrument makers in Elizabethan London appear to have had little contact except in two neighborhoods: the areas just outside the western walls of the city between the parishes of St. Clement and St. Dunstan in the West, and the neighborhood around St. Bartholomew's Hospital, which included parish churches of St. Bartholomew the Less, St. Bartholomew the Great, and St. Sepulchre.[50] Otherwise, the two groups tended to settle in different neighborhoods in the city, and few English practitioners worked for Strangers and *vice versa*.

This division of instrument makers into separate districts mirrors a striking division in workshop production: Strangers dominated the clock- and watchmaking industries, while English makers took preeminence in the field of mathematical instrumentation such as quadrants, astrolabes, staffs, balances, and other navigational instruments. Such a firm division of labor may well have had long-term implications for the development of a highly instrumental natural philosophy in seventeenth-century England.[51] Despite these differences, instrument makers shared some characteristics with medical practitioners, namely that family ties and interconnections featured strongly in their communities.

Two neighborhoods dominated by English instrument makers were the printing district centered on St. Paul's Cathedral Churchyard and the extramural parish of St. Botolph Aldgate. Five English instrument makers settled in St. Botolph Aldgate, which is striking because so many foreign-born surgeons, apothecaries, physicians, and aquavita distillers lived there. Three of these men—Richard Stevens (fl. 1569), Thomas Hearne (fl. 1592), and John White (fl. 1602/1603)—made compasses.[52] Yet the parish, in addition to housing many Strangers, also was home to a number of sailors, mariners, and shipwrights, which may indicate that there was a ready market of potential consumers. In addition, the distribution of active dates may be evidence of a single workshop.

Two notable instrument makers, James Kynvin (fl. 1570–1610) and Humphrey Cole (fl. 1568-91), lived around the precincts of St. Paul's Cathe-

dral. Kynvin was highly recommended by William Bourne. Gabriel Harvey, a staunch supporter of experiential knowledge who considered Kynvin "A fine workman, & mie kinde frend," noted in his copy of John Blagrave's *The Mathematical Jewel* (1585) that the paper dials which Blagrave set forth in his treatise could now be purchased in brass from his shop.[53] Some members of Elizabeth's court purchased instruments from him, including the Earl of Essex, who bought from him a combined compass and sundial enclosed in a box in 1593.[54] Humphrey Cole was a steady producer of mathematical instruments including pocket compendiums, navigational instruments, astrolabes, armillary spheres, ring-dials, sectors, gunners' scales, and theodolites.[55] Even Elizabeth purchased instruments from Cole, who like Kynvin received special mention by Gabriel Harvey who described him as a "Mathematicall Mechanicia[n]" in *Pierces Superogation*.[56]

Alien instrument makers, alternatively, preferred to settle in two former ecclesiastical Liberties: the Blackfriars and St. Martin le Grand. Of the two the Blackfriars was the more dynamic, with thirteen instrument makers known to have lived there during the Elizabethan period. The first alien instrument maker to settle in the Blackfriars was Thomas Gemini, whom Leonard Digges recommended to his readers in *A Boke Named Tectonicon* (1556), stating that Gemini was "dwelling within the blacke Friers . . . [and] is there ready exactly to make all the Instrumentes apperteynyng to this booke."[57] Another instrument maker, Eloy Mistrell, was one of the Blackfriars' more notorious residents. Mistrell was a French goldsmith who was arrested for counterfeiting and went on to be employed at the Royal Mint after receiving a patent for his novel machine for stamping coins.[58] Other instrument makers residing in the Blackfriars included three members of the Vallin family of clock- and watchmakers from Brussels; three members of the Noway family; Francis Rozean; Peter de Hind; Laurence Dauntenay; Thomas Tiball, a balance maker; and Mark Sara, a scale maker. It is difficult to assess their full importance in the history of Elizabethan instrumentation because so few of their works survive, but it is in clockmaking that the neighborhood appears to have made its reputation.[59]

Because of their expertise with clocks, many Stranger instrument makers found additional employment in London's parish churches, whose clocks were in perpetual need of repair and opened up a bottomless pit for parish revenues. The clock of All Hallow's Staining was fixed repeatedly by a number of experts between 1558 and 1579, including the royal clockmaker Nicholas Orshawe.[60] The clock at St. Helen's Bishopsgate was similarly troublesome, and French clockmaker John De Mellayne kept busy continually from 1565 to 1569 mending, keeping, and, most important, oiling it.[61] Similar positions in parishes all over the city provided the clockmakers with

an additional source of revenue, and heightened English residents' awareness of their skills and abilities.

Large-scale engineering and mechanical feats gave foreign-born technicians an opportunity to exercise their technical skills by bringing continental inventions into England. Elizabeth, who could be difficult in patronage matters, was unusually appreciative of the hard work that went into many inventions, as demonstrated by the case of William de Berger (fl. 1535–67), a coppersmith born in Utrecht. In 1559 he was given a seven-year license to make and sell a unique corn mill whose invention had "cost him much money and study during the past seven or eight years."[62] James Acontius, an Italian engineer from Trent, even received one of Elizabeth's rare annuities in exchange for his service to the crown.[63] Acontius's exemptions from guild control which were implicit in the patent became an issue for contention in 1566 when representatives from the Masons, Tilers, and Blacksmiths were called to the Repertory Court of Aldermen to be reminded of "the hole contents and effects of the Quenes Ma[jes]tyes hir patentes . . . in consideracon of a certon & goodly and wyttye devise by hym fyrst found and taught to her hygh[n]es subiectes for the makyge of furnesses."[64]

The importance of engineering and inventions to the state is demonstrated by the role that Elizabeth I's chief minister, William Cecil, played in supervising the patent process. Cecil's efforts ensured that there was an emphasis on output, adherence to a timely schedule, and ultimate English proprietorship over the skills of the inventors. To ensure that the crown's investment in the project was fruitful, patents were typically granted only if the work commenced within a proscribed time frame. When George Gilpin, an English merchant, and Peter Stowghberghen, a Stranger, were given the monopoly on "making ovens and furnaces after a new pattern, more economical of wood and other fuel, which they have invented," they were required to begin work within two months.[65] Failure to produce the anticipated results within another stipulated time frame was grounds for Elizabeth to pull her support entirely, as is vividly illustrated in the patent granted to Philip Cockerman, mercer, and John Barnes, haberdasher, who took over a monopoly on the manufacture of saltpeter once held by a German mineral expert, Garrard Honricke. They were granted a twenty-year monopoly, but were warned that they had only one year to demonstrate the usefulness and profitability of the process or their exclusive rights would be revoked.[66]

The influx of new skills and techniques that accompanied the Strangers into London was highly regarded by the City and the crown. Unlike other forms of natural science practice, instrumentation and engineering caught the attention of both common citizens and high-placed officials in Elizabeth's government. I would argue that such a wealth of technical expertise specifically caught the eye of Francis Bacon, who lived a stone's throw from

the St. Clement-St. Dunstan instrument-making neighborhood from 1576 when he enrolled in Gray's Inn. Though Solomon's House in the *New Atlantis* (1627) has always been seen as a prescriptive for scientific practice, it is clear from the examples above that Bacon did not need to actually dream up the displays of ingenuity and inventiveness that he described there. Elizabethan London—Bacon's London—had its own "engine-houses, where are prepared engines and instruments for all sorts of motions," its neighborhoods that produced "divers curious clocks," and its mathematical houses "where are represented all instruments, as well of geometry as astronomy, exquisitely made."[67]

ALIEN ALCHEMISTS AND THE ENGLISH ALCHEMICAL TRADITION IN LONDON

While Elizabethan instrument makers and engineers made visual spectacles of their inventions for the delight of the populace, London's alchemists labored in more private quarters conducting experiments and expounding upon theories that also promised great profit and rewards. Seventy-four alchemists are known to have practiced in the city during the reign of Elizabeth, and because this number is based on written remains it may well underrepresent the number of actual practitioners. Alchemical practitioners came from many occupations, including medical, metallurgical, apothecarial, and distilling trades. The alchemical papers that survive reveal a wide range of approaches, from the traditional to the Paracelsian.

No one neighborhood marked the center of alchemical practice; instead, alchemists were distributed throughout the city, from its crowded center to its more spacious suburbs. The highest concentrations of alchemists occurred in St. Botolph Aldgate, a relatively industrial area outside the city walls to the northeast, boasting four alchemists. St. Helen's Bishopsgate, which was just inside the city walls near St. Botolph Aldgate, had three alchemists. Most other parishes in London had one or two alchemical practitioners. Alchemists may have spread out in this fashion because their practices were so likely to annoy their neighbors with smoking stills, fires that were kept hot all day and night, noxious smells, and regular explosions.

There were instances, however, when the normally secretive practice of alchemy was performed on the public stage. One such incident involved a Polish alchemist, Cornelius Alnetanus, who defaulted on an agreement to transmute lead into gold after Elizabeth gave him a stipend and access to raw materials at the Tower of London's Mint. Hounded by William Cecil, who was determined to make him produce something useful given the substantial investments made by the Queen, Alnetanus became so concerned for

his safety that he tried to escape the crown's clutches by fleeing the country with the bankrupt Princess Cecilia of Sweden.[68] Even more public, however, were the alchemical controversies surrounding Frobisher's gold.

While much scholarly attention has been paid to this episode in the history of English navigation, the events surrounding the Frobisher's gold assays have not been investigated for what they can tell us about alchemical practice and the interactions between English and alien alchemists in Elizabethan London. The episode does indeed reveal rich information about these topics and highlights the place that alchemy could have in the English commonwealth. In addition, though alchemists lived all over London, the key players in the Frobisher assays all lived in close proximity in three adjacent areas of northeast London. Within the streets of the Bishopsgate, Aldgate, and Tower Hill were John Dee, Sir Thomas Gresham, the Muscovy Company, the Mint, the Royal Exchange, and virtually all of the alchemists involved in the controversy.

When Martin Frobisher returned from the New World with a dead Eskimo, a black rock, and some other curiosities, he had no idea of the excitement he was about to unleash. In October 1576 Frobisher gave Michael Lok, a London merchant and member of the Cathay Company, a small black stone that was discovered in present-day Baffin Bay.[69] Lok handed it to his wife, who, in a gesture of disdain for Frobisher's adventure, threw it into the fire, where it began to burn. Her curiousity stirred, Mrs. Lok retrieved the stone from the fire, washed the ashes away with vinegar, and discovered that it glittered like gold. [70]

Michael Lok was prompted by this discovery to give samples of the ore to three investors in the Frobisher voyages: Queen Elizabeth I's assay master at the mint and two members of London's powerful Goldsmith's company. When all three failed to achieve anything as encouraging as had his wife, Lok turned for assistance to a Venetian alchemist living in London, Giovanni Baptista Agnello, who may have been introduced to him through their mutual friend, John Dee.[71] Agnello was able to produce "a very little powder of gold" from the stone in early 1577. [72] Lok expressed astonishment, but Agnello assured him that his methods could be trusted because he knew "how to flatter Nature."[73] While Agnello continued to coax golden powder from the black rocks in subsequent trials, gossip began to circulate in London and the court about the mysterious substance. As the gossip swelled, so too did the reported value of the ore and the quantity thought to be available in the New World.

By the second week of January 1577, controversy erupted over the nature of Frobisher's gold. The controversy coalesced around three related issues: First, was the ore of any value? Second, who should be trusted with the heavy responsibility of assessing and then certifying the ore's value? And

finally, what method or methods should be used to extract anything of value that might be embedded in the ore? Once three English goldsmiths, a housewife, and a Venetian alchemist arrived at three conflicting assessments of the ore's value, it became a matter for open speculation within the metallurgical and alchemical communities of London, and separate trials of the ore began. The queen's master of ordnance, Admiral William Winter, set his own metallurgist, a Saxon named Jonas Shutz, to work on the ore assisted by his alchemically minded friends Sir John Barklay and Sir William Morgan.[74] The queen's notoriously suspicious advisor, Francis Walsingham, alarmed at the growing involvement of powerful people in London, sent his own samples to "certayne very excellent men" who reported that there was "nothing therein, but . . . a little sylver."[75] Walsingham's experts included the courtier-poet Sir Edward Dyer, who conducted his trials under Walsingham's skeptical eye; and a French alchemist living near the Tower, Geoffrey Le Brum.

While the ore was sent to various experts, Elizabeth became convinced of its value through the promising results achieved by a collaboration of Agnello and Shutz. Working together in furnaces at William Winter's house on Tower Hill, the two men "by . . . meanes of the learning of the sayd Baptista in alchimia and the knowledge of the said Jonas in myneralls and metalls handling," repeatedly gleaned gold from the ore.[76] While Jonas contributed the practical metallurgical knowledge for which Saxony was famous, Agnello's alchemical "learning" is more difficult to characterize, but it seems to have been a deft combination of medieval notions with a sprinkling of Paracelsianism for good measure.[77]

Working with metallurgical and alchemical techniques, Agnello and Jonas convinced Elizabeth and her Privy Council of the richness of the ore and were put into partnership. Disputes soon surfaced about the rightful place of alchemical practices in the trials of the ore, but a compromise method was reached: Agnello would handle the ore before it was put in the furnaces and supervize the chemical additives that would make the melting process easier; Jonas would then complete the process of melting and refining the gold in furnaces he had invented himself.[78] With Agnello tagged as the "chemical" man, and Jonas as the "furnace" man, the two men should have been able to work together in Winter's house toward their common objective.

The compromise failed when a second alchemist, an Englishman named George Woolfe, was brought in to assist Agnello. Lok was forced to admit that Agnello, Shutz, and Woolfe had irreconcilable differences in method and approach which threatened the progress of the trials. In late November 1577, Lok wrote: "the iij workmasters cannot yet agree together, eche is jelous of [the] other" and fears "to be put out of the work." What had been productive collaboration had turned into competition, and Lok reported

that the men were now "lothe to shew their conynge or to use effectuall conferens" with each other.[79]

While the disagreements raged on, other voices were raised. Urged by an unknown party to lend his experiences to the project, the queen's German physician, Dr. Burcot, "assayed and proved" that Frobisher's gold wasn't as rich as all had been led to expect. Instead of Agnello's gentle, alchemical flattery Burcot advocated a more aggressive and controlling approach to the materials in which the "roughe wyeld and forrayne" ore would "be well husbanded by a skyllfull and expert man."[80] Frobisher, smelling the first whiffs of disaster at the gap between Agnello's alchemical courtship and Burcot's metallurgical marriage, quickly threw in his lot with the queen's physician, and tried to sabotage the proceedings by spying on Jonas and Agnello.

At court, the Privy Council became concerned and sought the advice of "the goldesmithes and goldefyners of London and manye other namyd counynge menn," all of whom "had made many prooffes of the ewer and could fynde no whitt of goolde therein."[81] In response, Frobisher urged yet another collaboration—this time between Burcot and Jonas Shutz—and the controversy surrounding the ore and its parting turned into a tale of espionage and skulduggery. Throughout December 1577 and into the first months of 1578 the two Germans exchanged insults: Jonas accused Burcot of "evell manners" and of ignorance in "divers points of the works" while Burcot responded by announcing that "yf Jonas had any couninge" it surely should have yielded gold by now. The collaboration ended a few weeks later when Shutz and Burcot refused to have anything to do with each other, leaving only one line of communication between the two camps: the English goldsmith Robert Denham (d. 1605).[82] After all the controversy and contention, only Denham was able to turn the dross of the situation into a more profitable career. Denham was probably spying on both Jonas and Burcot and reporting directly to Elizabeth's Privy Council, resulting in his appointment as chief assayer on Frobisher's third voyage in the summer of 1578. Later, Denham became the director of operations in the royal mines.

As the evidence from the medical, instrumental, and alchemical practices makes clear, in the Elizabethan period natural science practitioners interested in the production of knowledge and the exchange of ideas were increasingly caught up in the international commercial environment that could be found at the Royal Exchange, where national independence was tempered by foreign contributions. The building itself reflected the blend of alien ideas and English knowledge that characterized natural science during the period much more than the local well at Bishop's Gate ever could. For the Exchange—supposedly the symbol of English economic independence—was built with English workers and European know-how and materials. The architect was Flemish; the stones came from Flanders; the

windows and wainscoting came from Amsterdam; and the design was modeled after the Bourses of Antwerp and Venice. While the Exchange may have been intended to announce that England had fully arrived on the international economic stage, it also served as a reminder of the country's ongoing relationship with the Continent and the Strangers in its midst. Approaching the history of science from below helps us to focus on the complex ways in which alien ideas and English knowledge were negotiated in the neighborhoods of London and then transformed into commodities to be exchanged. In doing so, it adds a new dimension to our understanding of scientific practices and practitioners in the early modern period.

Notes

1. John Securis, *A Detection and Querimonie of the daily enormities and abuses co[m]mitted in physick, Concernyng the thre partes thereof: that is, The Physitions part, The part of the Surgeons, and the arte of Poticaries* (London, 1566), sig. Biiiiv.

2. Elizabethans called residents who came from abroad "Strangers" or "Aliens," and those who came from parts of England outside of London "Foreigners." One of the greatest resources for studying these individuals is the four-volume *Returns of Aliens Dwelling the City and Suburbs of London from the Reign of Henry VIII to that of James I*, ed. R. E. G. Kird and Ernest F. Kirk (Aberdeen: Huguenot Society of London, 1900–08).

3. St. Martin Ludgate was home to nineteen surgeons between 1558 and 1603, including two masters of the company, Thomas Bird (fl. 1577–1607) and Edward Griffin (fl. 1563–96). One physician who lived in the parish during the Elizabethan period, William Harvey, was deeply interested in anatomical studies and went on to set forth theories on the circulation of the blood.

4. Richard Forster (or Foster, ca. 1546–1616) and John Dade (fl. 1589–1614) were both physicians. Forster taught Sir Christopher Heydon astrology, and published an ephemerides dedicated to Robert Dudley, earl of Leicester, titled *Ephemerides Meteorographica* (London, 1575) which is an extremely well-designed blend of technical and narrative information. His astrological manuscripts can be found in British Library MS Sloane 1713, ff. 1–9.

5. Forty-eight people who identified themselves as gardeners lived in the parish during the period from 1558 to 1603.

6. St. Benet Paul's Wharf was a small parish on the Thames where novelty and innovation were prized. Residents included foreign-trained physician John Osborne (fl. 1577–93), physician Richard Caldwell (ca. 1505–84) who possessed a number of instruments for use in surgical practice, and John Hester (fl. 1570–93), whom Gabriel Harvey described as "the alchemist of London" in his annotations on Hester's broadsheet *These Oiles, Waters, Extractions, or Essence Salts, and other Compositions* (London, 1585?), now in the British Library.

7. Population figures for the period are extremely difficult to state with great precision, but most historians estimate that London's population grew from about seventy thousand in 1550 to two hundred thousand in 1600. In 1571, the total population of London was approximately seventy-three thousand. Most historians use the figures generated by Robert Finlay, *Population and Metropolis: The Demography of London 1580–1650* (Cambridge: Cambridge University Press, 1981). See Finlay, p. 68, for estimates of the Stranger population, and p. 53 for figures regarding the London population more broadly.

8. There is a large and growing literature on the Stranger population and its significance in Elizabethan London. See Joan Thirsk, *Economic Policy and Projects: the Development of a Consumer Society in Early Modern England* (Oxford: Clarendon Press, 1978); Steven Rappaport, *Worlds within Worlds: Structures of Life in Sixteenth-Century London* (Cambridge: Cambridge University Press, 1989); Ian Archer, *The Pursuit of Stability: Social Relations in Elizabethan London* (Cambridge: Cambridge University Press, 1991); Andrew Pettegree, *Foreign Protestant Communities in Sixteenth-Century London* (Oxford: Oxford University Press, 1986); *Huguenots in Britain and Their French Background, 1550–1800*, ed. Irene Scouloudi (Totowa, N.J. : Barnes & Noble Books, 1987); Raingard Esser, "Germans in Early Modern Britain," in *Germans in Britain since 1500*, ed. Panikos Panayi (London: Hambledon Press, 1996), 17–27; Edward Chaney and Peter Mack, eds., *England and the Continental Renaissance: Essays in Honour of J. B. Trapp* (Woodbridge, Suffolk: Boydell Press, 1990); J. Arnold Fleming, *Flemish Influence in Britain* (Glasgow: Jackson, Wylie, 1930), Vol. 1; Henri Gorain, *Les Français a Londres* (Paris: La Vague, 1933); J. Van Dorsten, *The Anglo-Dutch Renaissance: Seven Essays*, ed. J. van den Berg and Alastair Hamilton (Leiden: E. J. Brill, 1988); J. Van Dorsten, *The Radical Arts; First Decade of an Elizabethan Renaissance* (Leiden: Leiden University Press, 1970).

9. My research to date has uncovered information regarding 1450 natural science practitioners who lived in London and its immediate suburbs who were active during the period from 1556 to 1603. Because of the patchy survival of Elizabethan records (whole volumes of state papers, parish records, and court cases have not survived), no accounting of practitioners can ever hope to be complete. Still, this number is much higher in every category (such as female practitioners, medical empirics, and alchemists) than one might expect.

10. George Baker, *The composition or making of the moste excellent and pretious Oil, called Oleum Magistrale* (London, 1574), 44v.

11. Securis, *A Detection and Querimonie*, sig. Ciiiv.

12. The three surgeons consisted of two English surgeons, Robert Clarke and Richard Wistowe, and foreign-born surgeon James Markady. On 16 March 1567/68 Parke was ordered by the company to remove this flattering self-description and "to sette his signe as other Surgeons do without any Superscription." Records of the Barber Surgeons, now London Guildhall MS 5257/1, f. 52r. Hereafter, London Guildhall manuscripts will appear as GH.

13. Repertory Court of Aldermen, Corporation of London Records Office Rep. 18, f. 107v. (hereafter CLRO Rep.)

14. Parishes that were one acre or less included St. John the Evangelist, All Hallows Honey Lane, and St. Mary Mounthaw. Finlay, *Population and Metropolis*, 170.

15. There is a vast literature on London's livery companies and guilds, but Joseph Ward's *Metropolitan Communities: Trade Guilds, Identity, and Change in Early Modern London* (Stanford, Calif.: Stanford University Press, 1997) is the finest account of the efforts of these organizations to foster community within the City. See also A. L. Beier, "Engines of Manufacture: the Trades of London," in *London 1500–1700: the Making of the Metropolis* ed. A. L. Beier and Roger Finlay (London: Longman, 1986), 141–167. Studies of specific organizations relevant here include Joyce Brown, *Mathematical Instrument-Makers in the Grocers' Company, 1688–1800, with Notes on Some Earlier Makers* (London : Science Museum, 1979); Michael A. Crawforth, "Instrument Makers in the London Guilds," *Annals of Science* 44 (1987): 319–377. Harold J. Cook, "Good Advice and Little Medicine: The Professional Authority of Early Modern English Physicians," *Journal of British Studies* 33 (1994): 1–31; Raymond S. Roberts, "The London Apothecaries and Medical Practice in Tudor and Stuart England" (Ph.D. thesis, University of London, 1964).

16. The Royal College of Physicians, London has a series of unpublished manuscript volumes of its proceedings in the period, known as the *Annals*. For references to Cornet see *Annals* 1: 8a.

17. CLRO, Rep. 15, f. 156r. The Royal College of Physicians attempted in that same year to shut down his practice. *Annals* 1: 22b.

18. *Annals* 2: 7a.

19. Ibid.

20. Ibid., 2: 7b–8a

21. John Wheeler, *A Treatise of Commerce* (London, 1601), 6.

22. For Barlow's medical prescription books of 1588–90 see Bodleian Library MS Ashmole 1487. The manuscript also contains a description of his library, which contained 172 books and his original manuscripts.

23. See *Annals* 2: 6b.

24. See Ann Vellam's will proven and registered in the Archdeaconry Court of London on 14 February 1570/1, now Guildhall MS 9171/3/269. In her will Ann bequeaths a case of knives to the Barber-Surgeons Company.

25. *Annals* 1: 33a.

26. Passing mention is made of Lieven Alaertes in Margaret Pelling and Charles Webster, "Medical Practitioners," in *Health, Medicine and Mortality in the Sixteenth Century* (Cambridge: Cambridge University Press, 1979) 179 (where she appears as Lieven Allette) and in Thomas Forbes, *Chronicle from Aldgate: Life and Death in Shakespeare's London* (New Haven, Conn.: Yale University Press, 1971), 194. Margaret Pelling has done more than any other historian to uncover the importance of empirical practitioners in early modern England. In addition to numerous pathbreaking articles she is the author of *The Common Lot : Sickness, Medical Occupations, and the Urban Poor in Early Modern England* (New York: Longman, 1998) and coeditor, with Hilary Marland, of *The Task of Healing: Medicine, Religion, and Gender in England and the Netherlands, 1450–1800* (Rotterdam: Erasmus Publications, 1996), both of which are germane to the subject of this paper.

27. George Baker, *The newe Iewell of Health, wherein is contayned the most excellent Secretes of Phisicke and Philosophie, devided into fower Bookes* (London, 1576), sig. *iiiv, sig. [*ivr] and p. 187v.

28. George Baker, *Oleum Magistrale* (London, 1574), sig. Ciir.

29. John Hall's translation of Lanfrank's *A Most excellent and learned woorke of chirurgeri, called chirurgia parva Lanfranci, Lanfranke of Mylayne his briefe . . .* (London, 1565), sig. [Miiir–Miiiir].

30. For a more detailed discussion of the Lime Street community, see Deborah E. Harkness, "Living on Lime Street: The Anatomy of a Natural History Community in Elizabethan London," forthcoming. For more on L'Obel and his significance in the history of botany, see Edward Lee Greene, *Landmarks of Botanical History*, 2 vols. (Stanford, Calif.: Stanford University Press, 1983), Vol. 2: 876–937; and A. Louis, *Mathieu De L'Obel 1538–1616. Episode de l'Histoire de la Botanique* (Ghent-Louvain: Story-Scientia, 1980).

31. The spelling of Russwurin's name appears to have given Elizabethan writers an unusually hard time. He is also known Valentyne Rawnsworm and Valentine Rushworm. Evidence surrounding the Russwurin case must be pieced together from the Patent Rolls, records of the Repertory Court of Aldermen, a treatise on the chemical analysis of urine and ocular medicine by Russwurin (British Library MS Landsdowne 101/4) which is undated but which must have been written by 1587, given its references to William Cecil's mother, who died in that year, and William Clowes's *A briefe and necessarie Treatise touching the cure of the disease called Morbus Gallicus, or Lues Veneres* (London, 1585). In modern scholarship I have found only passing references to Russwurin in R. Theodore Beck, *The Cutting Edge: The Early History of the Surgeons of London* (London: Lund Humphries, 1974), and Charles Webster, "Alchemical and Paracelsian Medicine," in *Health, Medicine and Mortality in the Sixteenth Century,* ed. Charles Webster (Cambridge: Cambridge University Press, 1979), 301–334, 317. For a more detailed analysis of

this incident, see Deborah E. Harkness, "Paracelsian Therapeutics in Elizabethan London: The Case of Valentine Russwurin of Schmalkald," forthcoming.

32. British Library MS Landsdowne 101/4, f. 15v

33. Webster, p. 305, where he cites *Calendar of Patent Rolls Elizabeth* 6: 261, 25 February 1574. Russwurin was made denizen only a few weeks before he ran afoul of Mrs. Currance.

34. Clowes, *Briefe and necessarie Treatise*, 10r.

35. Ibid., 11r.

36. CLRO Rep. 18, ff. 196r–v.

37. Clowes, *Briefe and necessarie Treatise*, 11r–v.

38. CLRO Rep. 18, f. 196r–v. The doctors consulted were Peter Symons and the Italian physician Julio Borgarucci.

39. CLRO MS Rep. 18, f. 211r. The second committee was far more English in its composition: Dr. Smith of Oxford, Dr. Smith of Cambridge, Dr. Waller, Dr. Gyfford, Dr. Borgarucci, and the Portuguese physician Hector Nonez.

40. Clowes, *Briefe and necessarie Treatise*, 12r. John Hester is a fascinating Elizabethan science practitioner who is well deserving of further study. William Eamon, in *Science and the Secrets of Nature* (Princeton, N.J.: Princeton University Press, 1994) refers to Hester in relationship to his association with the Italian practitioner Fioravanti on 254–255. Allen G. Debus also refers to Hester in *English Paracelsians* (Cambridge: Cambridge University Press, 1965), 101.

41. Clowes, *Briefe and necessarie Treatise*, 12r.

42. Ibid., 12v.

43. British Library MS Landsdowne 101/4, f. 12r. Though the treatise is undated, Russwurin's claim that "from my first co[m]minge into this lande . . . there hath not escaped, as I am credibly enformed, a meale or meetinge where any of the universitye Doctores have bene present, wherin I have not been backbytten, sclaundered, and also impudently . . . belyed," is in keeping with the general tenor of the events of 1574, f. 8r.

44. British Library MS Landsdowne 101/4, f. 14r.

45. For the Paracelsian emphasis on the chemical analysis of urine, see Allen G. Debus, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries*, 2 vols. (New York: Science History Publications, 1977), Vol. 1: 59, 109–110. For the medical implications of tartar in Paracelsian medicine, see Vol. 1: 107.

46. The historiography surrounding the adoption of Paracelsian ideas in Elizabethan England has split between the Kocher/Debus approach (which emphasizes the "compromise" between Galenic and Paracelsian ideas that was made by medical practitioners who disagreed with Paracelsian theories while being attracted to Paracelsian therapeutics) and the approach of Charles Webster, who emphasizes the enormous range and importance of Paracelsian ideas that circulated within England during the period. I believe that the evidence presented here and included in my larger study of natural science practice in progress points more in the direction of Webster's approach. See P. H. Kocher, "Paracelsian Medicine in England: (ca. 1570–1600)," *Journal of the History of Medicine* 11 (1947): 451–480; Allen G. Debus, *The English Paracelsians* (Cambridge: Cambridge University Press, 1965); Charles Webster, "Alchemical and Paracelsian Medicine," in *Health, Medicine, and Mortality in the Sixteenth Century*, ed. Charles Webster (Cambridge: Cambridge University Press, 1979), 301–334.

47. I have been unable to find any references to the outcome of the trial. No mention of Russwurin appears in the records of the Barber-Surgeons Company, and the *Annals* of the Royal College of Physicians for that year does not survive. For a list of works published in London that discuss Paracelsian theories and therapeutics between 1574 and 1580 see Webster, "Alchemical and Paracelsian Medicine," 333, Appendix 2.

48. CLRO, Rep. 15, f. 598v.

49. William Bourne, *A Regiment for the Sea: Conteyning most profitable Rules, Mathematical experiences, and perfect knowledge of Navigation, for all Coastes and Countreys: most needefull and necessarie for all Seafaring men and Travellers, as Pilotes, Mariners, Marchants &c. Exactly devised and made by William Bourne* (London, 1574), 58. For the importance of such recommendations to the London instrument-making trade, see D. J. Bryden, "Evidence from Advertising for Mathematical Instrument Making in London, 1556–1714," *Annals of Science* 49 (1992): 301–336

50. The area from St. Dunstan in the West to St. Clement contained the highest number of instrument makers, including four Strangers (Awdrian Gaunte, Robert Grynkin, Peter Dellamare, and Lawrence Fortuna) and English practitioners Thomas Brome, James Ilsberye, Richard Blunte, Charles Whitwell, John Modye, and Bartholomew Newsam. The St. Bartholomew's neighborhood had fewer practitioners, but they were relatively well-known and influential, such as Maryan de Lander and Michael Nowen (both immigrants) and Christopher Paine and John Reade. For a brief notice of Nowen, see Brian Loomes, *The Early Clockmakers of Great Britain* (London: NAG Press, 1981), 415. For brief notices of Christopher Paine and John Reade see E. G. R. Taylor, *The Mathematical Practitioners of Tudor and Stuart England* (Cambridge: Cambridge University Press, 1954), 189–190 and 185, respectively. Taylor's monumental contribution to the history of English mathematics was one of the first works to attempt to map mathematical practitioners (including instrument makers) within London.

51. The most recent and influential studies of the importance of instrumentation in England during the Scientific Revolution are Steven Shapin and Simon Schaffer, *Leviathan and the Airpump* (Princeton, N.J.: Princeton University Press, 1989) and Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1995).

52. Information taken from the will of Richard Stevens in the Archdeaconry Court of London, now GH MS 9171/3/225, and the parish registers of St. Botolph Aldgate, GH MS 9221.

53. Virginia F. Stern, *Gabriel Harvey: A Study of His Life, Marginalia, and Library* (Oxford: Oxford University Press, 1979), 85, 202. Harvey's copy of Blagrave is now at the British Library, and has copious notes. The notes on Kynvin were probably made between 1585 and 1590.

54. Loomes, *Early Clockmakers*, 346.

55. Taylor, *Mathematical Practitioners*, 171–172.

56. For further information on Kynvin see Loomes, *Early Clockmakers*, 158; Taylor, *Mathematical Practitioners*, 187.

57. Leonard Digges, *A Boke Named Tectonicon, briefelye shewynge the exacte measurynge, and speady recenynge all maner Lande, squarted Tymber, Stone, Steaples, Pyllers, Globes, &c.* (London, 1556), title page.

58. See PRO State Papers Domestic, Elizabeth: 12/19/35, 12/19/46, 12/22/22, 12/22/52. *Calendar of Patent Rolls Elizabeth* 2: 153 (a 1561 pardon for Mistrell's 1558 offense of counterfeiting) and British Library Landsdowne MS 14/8 (his 1572 petition for patents on new and improved machines for stamping coin).

59. Most of the information on these practitioners must be pieced together from extremely fragmentary evidence. Nicholas Vallin and Michael Noway are the exceptions, as a few items from their workshops do survive. There are references to the Vallin and Noway families in Loomes, as well as in George White, *The Clockmakers of London* (Hants: Midas, 1998), 1–8.

60. See GH MS 4956/2, f. 84v–132r for repeated references. In addition to Nicholas Orshawe or Urseau, John Portar, John Skrewens, Bruce Awsten, John Goldar, and John Newsam all worked on the clock between 1558 and 1579.

61. See references to John De Mellayne in GH MS 6836, f. 2r–9v.

62. *Calendar of Patent Rolls Elizabeth* 1: 39.

63. Ibid. 1: 254.

64. CLRO Rep. 15, f. 502r.

65. *Calendar of Patent Rolls Elizabeth* 2: 470.

66. Ibid. 2: 98.

67. Francis Bacon, *The New Atlantis* (1627), ed. Jerry Weinberger (Arlington Heights, Ill.: Harlan Davidson, 1989), 79–90.

68. James Bell provides an account of the scandalous visit of Princess Cecilia to England, and her connections to Alnetanus in *Queen Elizabeth and a Swedish Princess: Being an Account of the Visit of Princess Cecilia of Sweden to England in 1565*, ed. Ethel Seaton (London: Hawlewood Books, 1926). The state papers surrounding the case are scattered between the PRO, the British Library, and Hatfield House. For further information on Alnetanus see Deborah E. Harkness, "Queen Elizabeth's Alchemists," forthcoming.

69. Many of the state papers pertaining to the Frobisher voyages and the assays associated with them have been reproduced in Richard Collinson, *The Three Voyages of Martin Frobisher* (London: Hakluyt Society, 1867). For ease of reference, I will give references from Collinson unless the manuscript consulted was not included in his collection. For references to the exchange of the stone, see Collinson, 91. As for the stones themselves, they appear to have been some form of hornblende pyroxenite. See Stuart K. Roy, "The History and Petrography of Frobisher's 'Gold Ore'," *Geological Series of the Field Museum of Natural History* 7 (1937): 21–38.

70. George Best, *A True Discourse* (London, 1578), 98.

71. For Agnello, see Deborah E. Harkness, *John Dee's Conversations with Angels: Cabala, Alchemy, and the End of Nature* (Cambridge: Cambridge University Press, 1999), 204; Webster, "Alchemical and Paracelsian Medicine," 307, and Harkness, "Queen Elizabeth's Alchemists." From 1547 to 1549 "J. B. Agnelli & Co." were authorized by Wriothesley and Peckham to import gold bullion for use in the royal mint (see PROE/101/303/9). For more information on this incident see C. E. Charles, *The Tudor Coinage* (Manchester: Manchester University Press, 1978), 181. Agnello's alchemical treatise *Apocalypsis spiritus secreti* (London, 1566) was later translated by R[obert] N[apier]as *A revelation of the secret spiriti of alchymie* (London, 1623).

72. Collinson, *Three Voyages*, 92.

73. Ibid., "Bisogna sapere adulare la natura."

74. Ibid., 97–98.

75. Ibid., 97.

76. Ibid., 174–175.

77. There are scattered clues to Agnello's alchemical views. Agnello gave John Dee a Venetian book on alchemy—Giovanni Pantheus's *Voarchadumia contra alchimiam*—in 1557. See Julian Roberts and Andrew Watson, *John Dee's Library Catalogue* (London: Bibliographical Society, 1990), #D16 and p. 157. Though relatively unknown today, Pantheus, who proposed that practitioners return to a true, cabalistic alchemy, was one of those "most famous" alchemists mentioned by Agricola. Dee's marginalia in the *Voarchadumia* indicates that it was instrumental in the genesis of his *Monas Hieroglyphica* (1564). See Deborah E. Harkness, *John Dee's Conversations with Angels*, 88–89. Agnello's own alchemical text, *Revelation of the Secret Spirit,* is consistent with the ideas expressed in medieval alchemical texts, but in the second part, Agnello emphasizes the importance of salts to alchemical processes. Robert Napier, who translated the text from Italian and Latin into English in the first quarter of the seventeenth century, enthused about Agnello's "practical search . . . [for] that Chrystalline . . . Salt" which was so prominent in the writings of Paracelsus.

78. Collinson, *Three Voyages*, 175

79. Ibid., 192.

80. Ibid., 194

81. Ibid., 176.

82. Ibid., 176–178, 181.

Part 2

NETWORKS OF KNOWLEDGE

Commerce and the Representation of Nature

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Local Herbs, Global Medicines

Commerce, Knowledge, and Commodities in Spanish America

ANTONIO BARRERA

On 14 September 1501, Diego de Lepe, a resident of Palos, Spain, received a royal license for trading in the New World with gold, silver, copper, mercury, and other metals, jewelry, and gems. In addition, the royal license acknowledged the possibility of valuable unknown entities by granting Lepe the right to trade in "plants and animals of any quality, fish, birds, species and drugs, and any other thing of any name and quality even if they are of a higher value than those already mentioned."[1]

This royal license assumed that there would be new entities of unknown qualities and names, with potential commercial value in the European market. If there were new entities of unknown qualities and names, how to discover their qualities and economic value? In general, how did the Spaniards study the New World entities and how did they find the qualities of these new entities? What practices did they establish for organizing and using information about the nature of the New World, and with what purpose?

Spaniards needed to learn about these things not only for commercial purposes, but for their own health and living conditions (food, construction, ornaments). Health issues were particularly important because many Spaniards who arrived in the New World soon became sick, melting in their European clothes. Many would die in the Caribbean islands, weak and sick after a long and difficult voyage.[2] They passed on their diseases to the Native Americans, who would die in massive numbers, weakening the survivors' ability to halt the new invaders.[3] In the early phases of contact, health issues might have constituted a common concern for both indigenous people as well as for Spaniards. Moreover, sometimes the medicines the Spaniards brought with them were already dated, or did not last long in the new environment.[4] It is not difficult to imagine an apothecary or a physician asking the native inhabitants of the Santo Domingo port (the main port of entrance to the New World in the early sixteenth century) for their med-

icines and herbs — not only to replace their own medicines but for commercial purposes. This article explores the interactions between commerce and knowledge in the production of empirical practices as well as the roles played by the Spanish state and entrepreneurs in shaping those practices through the case study of a drug found in the Hispaniola, the Santo Domingo balsam.[5]

The story of the Santo Domingo balsam belongs to the intersection between the history of European state formation, the history of science, and the history of the Atlantic encounter. As the Spanish Empire established institutions and laws in the American kingdoms and as commercial interests brought New World commodities and curiosities to Europe, empirical practices developed for taking possession of nature in the New World.[6] In the case of Spain, these empirical practices were institutionalized first at the Casa de la Contratación (f. 1503) and later at the Council of the Indies (f. 1524), as well as at the royal court, the viceregal courts in the American kingdoms, and the Royal Academy of Mathematics in Madrid (f. 1584).[7]

The history of science and the history of the New World are intimately related. The European understanding of the New World's nature passed through a rapid process of transformation after Columbus's landing.[8] It shifted from an image of paradise as described by Columbus to an overtly pragmatic image deriving from personal accounts such as that of Dr. Chanca to the city officials of Seville in 1494, or the letter of Michele de Cuneo to his friend Hieronymo Annari, both of which discussed natural resources in concrete and practical terms.[9] This shift occurred largely as a result of the material culture that shaped the European encounter with the New World. The encounter of new lands provided merchants and royal officials with untapped commercial possibilities. Europeans explored the new lands to find new routes to the East and commodities for the European market. In the process Europeans occupied and colonized the New World. The main purpose of these explorations was to find new sources of revenues for the state. During the explorations, some European notions of nature and experience were displaced from their traditional literary contexts. Classical notions did not account, for example, for the size of earth, a new continent, life in the Torrid Zone, manatees, and guayacan (a New World medicine, later used to treat syphilis).

Experience gained in exploration and in contact with other cultures increasingly displaced classical sources as the authority for knowledge. The natural products of the New World lacked referents in the classical sources. An avocado was nowhere to be found in Pliny or Aristotle, thus the empirical information about avocados — or pineapples, iguanas, mountains, rivers, or herbs — became an alternative and more reliable source of knowledge than the imperfect knowledge contained in classical sources. Thus, the tra-

ditional notion of experience, bound to Aristotelian texts, gained a new autonomy within the commercial and imperial needs of the encounter, where experience assumed a new role in validating knowledge.

The need to control faraway lands brought together royal bureaucrats, merchants, pilots, and cosmographers in an effort to produce practical knowledge that could be used to govern the new lands and profit from its resources.[10] This effort led to the development at the Casa de la Contratación of intensely scrutinized and increasingly standardized mechanisms for gathering, producing, and distributing useful knowledge about the New World. The institutionalization of these offices and practices created a veritable Chamber of Knowledge at the Casa de la Contratación: a set of offices and professionals in charge of collecting navigational and geographical knowledge about the Indies, systematizing this knowledge, disseminating it (teaching), and making new tools with this knowledge (instruments and charts). The practices developed there reshaped the status and application of personal experience in the creation of authoritative knowledge about nature, particularly in the guise of cosmography and navigation. The use and development of navigational techniques and instruments, and the establishment of juntas of theoretical experts and practical people at the Casa de la Contratación played as important a role in those domains as it did in the realms of natural history and medicine.[11] Years later, the Council of the Indies would implement similar empirical practices also with the aim of establishing valid knowledge in natural history and medicine.

At the center of these empirical practices was the need to control human and natural resources in the New World and, in particular, to control the search for things that could bring profits in the Old World. The case of the Santo Domingo balsam shows how empirical practices emerged from entrepreneurial, imperial, and commercial contexts in sixteenth- and seventeenth-century Europe. It also illustrates how empirical practices that emerged from commercial interests influenced the development of knowledge production practices regarding resources from the New World.

TESTING NATURE

Balsam was an old and celebrated classical medicine. According to *Dioscórides*, Judea and Egypt produced balsam, but only in very small quantities; a circumstance that encouraged the selling of fake balsam. The liquor of balsam was better than its fruit or wood. The liquor "was very effective, for its very hot quality."[12] It was used to cure vision problems, to purge, to provoke menstruation and childbirth. It also helped to heal wounds, to provoke urine, and to mitigate fatigue; it was a good antidote against poison.

Balsam was almost an all-purpose medicine in this period and in high demand. However, the production of Egyptian balsam had already stopped by the early fifteenth century as the traveler Pero Tafur, to his consternation, discovered when he visited Matarea, Egypt, in the late 1430s.[13]

The garden of Matarea had been, according to legend, the place where the Virgin Mary had found water when she and her son escaped to Egypt. This water irrigated the balsam of Matarea. A well-informed humanist such as Peter Martyr (1457–1526) did not know that the production of the Matarea balsam had come to a halt until he visited this garden in 1502 and found that the fountain of water was already dry and the production of balsam had stopped.[14] When Antonio de Villasante, a resident of Santo Domingo, claimed to have found a similar product in Hispaniola and that he was willing to exploit it with royal help, the crown supported him. There was already a high demand for balsam in the international drug market, and the discovery of balsam in Hispaniola came just in time to supply this market.

The discovery of the Hispaniola balsam, however, came not only as the result of commercial demand but also as the result of an informal search for curiosities in the New World. In 1525, the humanist Peter Martyr obtained a royal decree that ordered ships' masters to bring animals and plants such as parrots, "turkeys from Tierra Firme," "other strange birds," fruits, iguanas, chilies, cinnamon, roots, blue stones, amber, or "any thing" that the officials from Hispaniola would want to send him.[15] At the same time, Charles V asked Gonzalo Fernández de Oviedo to write a natural history of the New World; Oviedo published a *Sumario de la Historia Natural* in 1526. It was in this context of interest in curiosities from the New World that Antonio de Villasante would a few years later present his report on balsam.

We know little about Antonio de Villasante. The scholar Ernst Schäfer maintains that Villasante was already a resident of Santo Domingo by 1514.[16] He received thirty-five indigenous people, Tainos, in encomienda.[17] He married Catalina de Ayahibex, a chief, or *cacica*, who had converted to Christianity. He became friend of the viceroy Don Diego Colón and later obtained a license from him to exploit balsam and other drugs on the island. Villasante then traveled to Madrid to secure a monopoly for the exploitation of this and other drugs (escormonea, rhubarb root, aturbin, polipondyo, acubebas, atiribinro, and myrrh) in the Caribbean.

Early in 1528, Villasante had obtained from the crown the right to exploit balsam on the condition that he present before the Council of the Indies "a long and very complete report about the tree to obtain the already mentioned liquor, and what its shape is and where this tree is found and what method is used to obtain the liquor; and similar [information] about other drugs."[19] The crown requested an empirical and practical report about balsam

and other drugs, and a few months later Villasante complied, presenting a report on Santo Domingo balsam before the Council of the Indies.[19]

Villasante told the council that his wife, whom he described as "an Indian, *cacica*, and Christian," and her family had taught him about the properties and uses of diverse medicinal plants from the island, one of which was balsam.[20] Villasante thus established the authority of his native, female informant. Because Catalina de Ayahibex was a *cacica* and a native, she knew about the resources of her island. She may have been one of the last survivors of the island by this time.[21] Moreover, she was Christian and thus trustworthy. Villasante declared that he would state everything he knew about the plants, so the king or his officials could, eventually, find and exploit them. The issue of secrecy became irrelevant, for Villasante's purpose was to obtain a commercial monopoly over balsam. It was to his benefit to provide all the necessary information for its commercialization and sale.

After establishing the authority of his sources and information, Villasante continued with a description of balsam. He explained that he knew from experience that in Hispaniola, near Santo Domingo, there was a tree called balsam in Spanish and *boni*, *guacunax*, or *canaguey* in the native language, depending on the province. He described the tree, its height, girth, color, and leaf shape, the color and smell of the bark, type of fruit, and habitat.

The tree was three yardsticks tall, and grew around rivers and wet areas; it was about as thick as a human arm. The mature ones were bushy-topped trees; the leaf was very green and in the shape of a rhombus. He then provided the royal officials with a very schematic drawing of a leaf. The bark smelled and looked like cinnamon and tasted good, although it was a little hot and sour. The tree produced a fruit like the pepper tree, he concluded, but thicker.[22]

Villasante knew that the credibility of his report depended on the authority and knowledge of the indigenous people and on his direct access to that knowledge. And the council was by then well aware that Spaniards needed the knowledge of the indigenous people to survive and move around the New World; in this area, as in many others, indigenous people had the advantage. Villasante told the council that "the indigenous people affirm that there are many other beneficial trees and drugs in the Indies," and he promised to send reports on these as he learned about them.[23]

Villasante, however, relied not only on indigenous knowledge to support his information but also on the language of commerce. His intended audience, the Spanish bureaucracy and his commercial partners, shaped his description of balsam. The very name *balsam* that he used to translate the indigenous names *boni*, *guacunax*, or *canaguey*, was connected with an existing commercial drug. But to make his point even more explicit, Villasante compared the Santo Domingo balsam with pepper and cinnamon, two valu-

able spices in the international trading system at this time. The search for spices and medicines, which had begun with Columbus, continued with Villasante and with the efforts of merchants and the crown to find new drugs and spices as well as plants and animals "of any quality and name" in the New World for commercial purposes.[24]

Villasante confirmed his wife and her family's knowledge and the commercial possibilities of the balsam by performing tests with it—what he called "*esperiencias*." After describing the tree, Villasante provided the method he used for preparing balsam brew. Villasante cut the branches with a knife and took off the leaves and seeds with his hand; using his hands, he shredded the pruned branches together with bark from the trunk; he pounded this mixture with rocks; and finally he chopped it into pieces with a knife. He then warmed the mixture in a clay pot with water. Once the mixture had soaked awhile, he took it out of the clay pot and squeezed it to obtain a liquor. Villasante finally heated the liquor in a small pot, which was inside a bigger one full of ashes, until it was reduced to a thick liquor.[25] Sometimes he would put the liquor to dry under the sun with the same results. He also mentioned that he once had cut the trunk of the tree with a knife and that a "liquor" came out. This sap, "as it was coming out, hardened like gum," he said, "and of this hardened [substance] I did not make any other test or experience."[26]

According to Villasante's "experiences" in the New World, in Seville, and at the court, balsam was effective for healing wounds in a short time. It was also useful for healing all types of abrasions, and for relieving stomach pain. Balsam was therapeutic for the liver and gallbladder, for treating gout, and, finally, for relieving toothache. Villasante expected that the knowledge about his balsam would increase, accumulate, and become more perfect with time and new tests since, as he himself reported:

> This [balsam], by experience, shows already that it is beneficial for the diseases that I have mentioned. With time it may be shown by experience or reports from physicians whether it might be beneficial for other things, and they could also reveal the method for the perfection of this liquor and balsam.[27]

Villasante assumed that knowledge about balsam was cumulative and would be based on the experience of physicians. This was a common tendency in the production of knowledge related to the New World, and echoed the model used at the Casa de la Contratación. Only through the accumulation of information and the correction of previous information through new empirical information could physicians, cosmographers, and natural historians complete their study and understanding of the New World.

Villasante called on his own experience in the preparation and uses of balsam to, first, mediate the transfer of knowledge from the indigenous people to the Spaniards, and, second, validate his commercial interests. Villasante based his knowledge about balsam upon the expertise of Catalina de Ayahibex and, more important, upon his own tests with balsam in the New World as well as in the Old World. Note Villasante's method of presentation here. He did not place balsam within the Galenic framework, for instance, as the physician Garciperez Morales would do a few years later:

> Of this precious liquor, commonly called balsam, which is brought from Santo Domingo of the Indies: its first virtue is hot in the second grade, or a little less; dry in the first metha of the third [grade], or a little more.[28]

Garciperez Morales would write his treatise at the request of the crown in 1530. His audience consisted of royal physicians at the court and regular physicians in Spain, such as his student Nicolás Monardes, who would become well-known for his research on American plants.[29] Morales framed his treatise in classical and traditional terms familiar to him and to his audience. Villasante, by contrast, framed his account in empirical terms for his audience of Council of the Indies members and his commercial partners. The difference in audiences, with their diverse interests and backgrounds, explains the difference between Villasante's and Morales's approach to the Santo Domingo balsam, a difference not unlike that between the practical pilots and learned cosmographers at the Casa de la Contratación. In addition, Villasante had firsthand experience of the New World and knowledge provided by indigenous people while Morales had neither this experience nor this knowledge.

Villasante's empirical approach to nature was not new to the Spaniards in the New World. Since the mid-fifteenth century, both nominalists and humanists had emphasized the collection of empirical evidence to solve internal problems in their textual sources. What was new to Villasante and the Spaniards in the Indies was the intense use of empirical evidence in describing the things they encountered, the elaboration of their reports outside the traditional frameworks of knowledge, and the institutional role played by the Spanish monarchy in this not yet formalized project of research. The relevant framework here was the exploitation of commodities for the European market.

The interest of the crown in the commercialization of balsam, for instance, shaped its decision regarding not only the production of balsam, but also the validation of empirical knowledge about balsam. For the production of balsam, the crown granted Villasante, his heirs, and whomever else he deemed appropriate a complete monopoly on the Santo Domingo

balsam as well as on the other drugs he would find in the New World.[30] Villasante also obtained, in perpetuity for himself and his heirs, the alcaldía of the fortress of Santo Domingo, Indian labor, tax exemptions, and other prerogatives.[31] The exploitation of balsam seemed to be ready. Other experts in the field, however, soon challenged Villasante's report.

TESTING EXPERIENCE

In 1529 a competing report about balsam came to Spain from the Hispaniola physician Licenciado Barreda, challenging Villasante's report. Barreda, who has been the Inquisition's physician, left Spain for Hispaniola with Pedrarias Dávila's expedition to Panama (1513–14).[32] In December 1513, the crown had ordered the Casa de la Contratación to pay 12,000 maravedis to Barreda for his travel expenses.[33] In Hispaniola, he held the title of royal physician for some time until 1519, when the crown suspended his title.[34] In 1526, Barreda was appointed official physician of Santo Domingo.[35] By the time Barreda wrote his report on the so-called balsam of Santo Domingo in 1528, he had been in the New World almost fifteen years.

In his report, Barreda argued that the crown had been deceived by the physicians who "approved as balsam the liquor that the aforementioned Villasante" took with him to Spain.[36] Barreda claimed that the royal support for this drug, "approved" as balsam by physicians in Spain, would harm the person and property of the crown's subjects. He criticized the fact that the physicians in Spain did not discuss the matter of the balsam with their colleagues in Santo Domingo:

> [Spain's physicians] know or should know that they [Santo Domingo's physicians] do not lack letters, nor extensive experience, nor knowledge of the tree, its fruit and leaves and the methods to apply the aforementioned liquor that comes from this tree.[37]

For Barreda the lack of interest on the part of the Spanish physicians in sharing their opinions and in consulting their learned and experienced counterparts in the New World were an offense and a great mistake, which led the crown into a dangerous deception. He emphasized the possible financial and health consequences of using a fake balsam for the kingdom. Barreda's report helps to uncover the link between knowledge and political and economic power in sixteenth-century Spanish America. Knowledge pertaining to the New World, claimed Barreda, had to be articulated by those with direct experience of the New World. Physicians in the Old World, despite their "letters," did not have this experience. For this reason, they needed to

consult with their counterparts in the New World. Otherwise political and economic decisions regarding the New World could harm the subjects of the king. In the interest of the common good, personal experience was a better source of knowledge than "letters" alone. The crown and its institutions, the Council of the Indies and the Casa de la Contratación, adhered to and supported this view. The issues at stake concerned who would control the production of knowledge — the crown in collaboration with entrepreneurs such as Villasante, or physicians such as Barreda?

Once Barreda had established his authority based on his expertise and personal experience, he moved into the description and uses of Villasante's liquor and compared it to balsam. Villasante had applied the same empirical model to his own account of the balsam, but he did not compare his liquor with the original, Old World balsam; he assumed that they were similar. Personal experience is always fragmented and based on the personal background of the informer or informers. How could these two accounts, both based on experience, be reconciled? Which one was more reliable?

Both Villasante and Barreda argued that their respective accounts were true because each one was based on personal experience and experimentation. What mechanism could be established to determine the truth of the matter? In the case of the pilots and cosmographers, the crown established the mechanism of juntas to determine the truth of different accounts by consensus. In these juntas the experience of pilots together with the formal knowledge of cosmographers came together to produce new knowledge about the New World.[38]

The crown established a similar solution in the case of the New World balsam — perhaps taking a hint from Villasante's suggestion that "with time it may be shown by experience or reports from physicians whether it might be beneficial for other things." The crown, after learning of Licenciado Barreda's account and other similar accounts, requested that different Spanish physicians and hospitals carry on experiments with the balsam. Barreda had provided a convincing case for his own account. He noted the differences between classical balsam and the "liquor that Villasante" took to Spain:

> [The] main virtue of this liquor is to restrain the blood in fresh wounds by pressing it over them, and [to restrain] the flow of blood from below [rectum], this virtue, either called opilativa . . . or constritiva . . . , in what books does it appear that balsam has this virtue?[39]

Certainly classical texts on medicine such as Dioscórides's *Materia medica* did not list this virtue among those attributed to balsam.[40] Barreda also compared the trees and the different methods to obtain the liquor from each type

of tree before concluding that Villasante's liquor was not the authentic balsam. By the mid-sixteenth century, such scholars as Gonzalo Fernández de Oviedo, Andrés Laguna, Nicolás Monardes, Pedrarias de Benavides, and Conrad Gessner would agree with him.[41] Nevertheless, Barreda found that this "liquor has other virtues experimented by me [*por mi spimentadas*]."[42] He found that the Santo Domingo balsam was efficient for healing rheum, and kidney and stomach "passion."[43]

Dr. Barreda was not alone in his criticisms. In 1530, the crown claimed that there were already "some physicians, surgeons and other people who, without complete information on the balsam recently discovered in our Hispaniola and without yet having made any experience with it, have published and continue to publish some publications (*ynpreciones*)"[44] against it. Moreover, people had decided not to buy the new balsam because of these publications, which "harms the health of the sick and wounded, and our royal treasury."[45] Such publications indicated that criticism had merit, but the battle for true knowledge about the balsam had just begun.

The crown sought to control and discipline this group of dissident physicians by ordering that

> physicians, and surgeons of any city, town and place of our kingdoms and possessions should have unequivocal information [*cierta noticia*] about this balsam before they talk or publish works, and when, by experience or by other method, they find out that it is harmful for wounds or any other illness, they should declare and reveal it to our local magistrates.[46]

Meanwhile, local magistrates should try to foster the sale of balsam "in the best way they see fit."[47] The crown sought to control dissident physicians by ordering them to speak or publish only after they had made experiments with the balsam, for which they had to buy it. Furthermore, they had to bring their experimental findings before local magistrates, who would send them to the crown. By asking physicians to experiment with balsam and then to show their reports to royal officials, the crown controlled the production of knowledge about the balsam. This situation shows the interplay between the production of new medical knowledge and the political and economic interests of the crown in controlling this knowledge and its products. In this particular case, controlling knowledge about balsam amounted to controlling the possibility of its commercialization.

With the 1530 decree to royal officials, the crown established a protocol for the articulation of empirical information about Santo Domingo balsam, namely, experimentation with samples and the recording of findings. Again, this model resembles that of the Casa de la Contratación case in which cosmographers and pilots appointed by the crown organized empirical infor-

mation about navigation and geography provided by pilots. In the interplay between the interests of the crown and the interest of individual subjects there arose a scientific practice based on empirical experimentation ("*experiencias*") and the collective articulation of the resulting information.

The crown, however, not only attempted to discipline dissident physicians into experimenting with the balsam; it also ordered particular physicians, surgeons, and hospitals to carry out experiments with the New World balsam. The crown had listened to the dissidents and sought to produce accurate knowledge about the balsam. Following its own protocol, the crown sent samples of balsam to physicians and hospitals for experimentation. In one case, the crown sent a sample of balsam, useful to "cure injuries and many illnesses," to the hospital of the cardinal in Toledo for use on patients chosen by the physicians and surgeons of the hospital. The crown requested the hospital administrators "to be attentive to inform us of the cures and experiences realized in the hospital with this balsam."[48] Hospitals in Seville, Burgos, Galicia, and Granada received similar orders.[49]

Furthermore, the crown brought particular physicians into the project for testing the Santo Domingo balsam. The physician Andrés de Jodar, for instance, a resident of Baeza, received the order to use balsam for those "cures and experiences" that he would deem appropriate.[50] Moreover, whatever he found, by means of "art" and experience, "certain and true," he should "put in writing," "sign" his report, and send it to Villasante's partners in Spain. Twenty-two physicians and surgeons in different cities of Spain received similar orders.[51] Villasante's partners, Franco Leardo and Pedro Benito de Basniana, would use these reports for the commercialization of balsam in Spain. They hired some physicians and surgeons to help them in the commercialization of balsam.[52]

By 1532, information was already arriving to the court. A certain Juan de Vargas had been using the "balsam from the Indies" to heal the sick.[53] He seemed to have been quite successful, for the crown ordered the officials of Cuellar to collect information from patients who had been healed with Santo Domingo balsam. The scribe of Cuellar, Melchor de Angulo, received the information and sent it to the crown. He received 108 reals for the eighteen days he worked on this assignment.[54] The crown also requested Juan de Vargas to come to the court, which he did in late 1532 or early 1533.[55] During his stay there, he tested the balsam and was paid for his work.[56] Still some medical practitioners opposed the use of this balsam and maintained it was fake. In 1539, the physician and apothecary of the village of Amusco denounced Vargas for using the New World balsam. The authorities of Amusco arrested him and took his balsam. He was later released; the crown asked the authorities of Amusco to explain the matter.[57]

In the end, the crown could not dismiss Barreda's contention that the Hispaniola balsam was not authentic. However, the only thing that mattered to

the crown was the fact that this balsam was especially good, as both Villasante and Barreda had argued, at treating wounds. The crown sought, first, to develop the right method to use it; second, to end the confusion between New World balsam and classical balsam; and, finally, to convince other physicians that it was a worthy medicine. The dissident group of physicians in Santo Domingo and Spain were controlled and disciplined by requesting them to experiment with the balsam and to send their results to royal officials—they could not publish or discuss their findings without royal approval. Simultaneously the crown and Villasante's partners hired a group of physicians to legitimize the use of balsam in their practice. The name balsam, given by Villasante, was a propagandistic device to sell this new drug. The physician Monardes, years later, commented that the liquor "received that name because it produces great effects and cures many illnesses,"[58] as had the classical, Old World balsam.

The economic possibilities of balsam shaped the research on it. This research was characterized by, first, empirical observation, that is, knowledge about products of the New World came from "experiences"; second, professionals and experts collectively articulated this knowledge; and, finally, the crown arbitrated the outcome of disputes about knowledge in light of its economic and political goals. In its role as knowledge broker, the crown established a protocol for research, which fostered economic and commercial interests. From these interests emerged the empirical practices that characterized the long-distance control of the New World. The balsam episode helps to understand the significant emphasis placed on empirical approaches to natural products of the New World, approaches that resulted from the commercial and imperial activities of Europeans outside Europe.

The encounter with the New World slowly displaced European notions of nature and experience, which had been closely tied to textual practices.[59] Physicians such as Barreda and entrepreneurs such as Villasante as well as cosmographers and pilots at the Casa de la Contratación, natural historians, and explorers reexamined those notions to accommodate the increasing flow of new knowledge circulating between Spain and America. Certainly, initial information about new drugs came from books, but it was the testing of new drugs, for instance, that provided final knowledge about them. European notions about nature were adapted thus to incorporate discrete local settings, soon to become gardens of knowledge, into an emerging global framework of communication and trade.[60]

Simultaneously, local natural settings were adapted to fit European objectives and strategies with regard to trade and the exploitation of natural resources. Contact with the New World accelerated this process of transforming and exploiting nature. In this emerging global context, nature was largely secularized and approached in empirical terms. Nature became a con-

tingent reality adaptable to human plans and needs and a collection of commodities, such as balsam, or curiosities ready for exploitation or collection.

From about 1500s through the 1560s, this secular or practical approach to the natural world fostered informal, nonsystematic empirical research into the natural products indigenous to the New World. During the sixteenth century nature was described and studied increasingly through empirical terms as more groups joined this collaborative enterprise. The balsam episode illustrates this development. By the late sixtenth century there was already an international network of scholars, including such well-known figures as Carolus Clusius and Antonio Recchi, studying American nature through Spanish gardens, books, and collections.[61] Nature's commodities were tested at the courts, hospitals, and gardens; nature's curiosities were collected, studied, and described. These empirical practices would first become practical knowledge at the Casa de la Contratación and at the Council of the Indies before becoming institutionalized as science in the form of natural history, cosmography, geography, and choreography.

The balsam case constitutes just one episode in the establishment and institutionalization of empirical practices for controlling natural resources in the New World. As the Spanish crown faced particular problems about understanding and exploiting new products, it sought to create systematic methods for the production of knowledge about the New World. As the American enterprise developed, and as more groups became involved in it, empirical information became increasingly more relevant and significant in the production of knowledge. But one report, even if it is based on direct personal experience, does not constitute knowledge. Consequently, the crown sought to establish conditions for the production of several reports based on testing and experimentation. The balsam case illustrates this method. The first notice comes from Antonio de Villasante, who learned about this medicine from the Tainos, in particular, from his native wife. Soon, competing reports challenged Villasante's characterization of this medicine as balsam, and the crown sent samples of the balsam to several hospitals and almost two dozen physicians in Spain for testing the medicine on patients. Whether or not this medicine was placed in a Galenic theoretical framework, the issue at stake remained an empirical one: the practical uses of the medicine, which could be found only through experience, as was the case with the navigation to and mapping of the New World, the exploitation of other resources, and the control of its human resources. The development of empirical practices are at the center of the American enterprise; they made possible the conquest and commercialization of the new resources. Such practices are also at the center of the modern world.

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1. Cédula Real a Diego de Lepe on 14 September 1501, Archivo General de Indias, Indiferente, 418, L. 1, ff. 29v–32v. From now on I refer to the Archivo General de Indias as AGI.

2. Columbus was particularly concerned with this problem. In his second voyage many of his people arrived sick or became sick afterward, and there were not enough medicines for them. See the so-called Torres Memorandum of 30 January 1494 in *Cristobal Colón: Los cuatro viajes, testamento,* ed. Consuelo Varela (Madrid: Alianza Editoral, 1986), 209, 211. The expedition of fray Nicolás de Ovando, who was appointed governor of the Indies in 1501, was well provided with medicines and some medical instruments. See the list of medicines in Angel Ortega, *La Rábida. Historia documental crítica* (Seville: Impresora y editorial de San Antonio, 1925), 315. From Santo Domingo, however, Ovando asked the crown to send more medicines and apothecaries, a request that was granted. See Cédula Real a Fray Nicolás de Ovando, 11 November 1505, Salamanca. AGI, Indiferente, 418, L. 1, ff. 185v–186r. On occasion the crown sent orders to treat those arriving in the Indies. Thus, in 1544, the crown ordered the officials of Hispaniola to cure the friars arriving on the island because they would probably arrive sick. See Cédula Real a los oficiales de la Española, 23 February 1544. Valladolid. AGI, Santo Domingo, 868, L. 2, f. 208v. There was a name for a particular sickness that the Europeans suffered as they arrived in the Indies: *chapetonada*. According to the surgeon Pedro Arias de Benavides, those who survived it would live for many years. See Arias de Benavides, *Secretos de Chirurgia, especial de las enfermedades de Morbo galico y Lamparones y Mirrarchia, y assi mismo la manera como se curan los Indios de llagas y heridas y otras passiones en las Indias, muy util y provechoso para en España y otros muchos secretos de chirurgia hasta agora no escriptos* (Valladolid: Impresor Francisco Fernández de Carbona, 1567).

3. On the role played by disease in the conquest of the New World see Alfred Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, Conn.: Greenwood Press, 1972); and Noble David Cook, *Born to Die: Disease and New World Conquest, 1492–1650* (Cambridge: Cambridge University Press, 1998). Cook also discusses the consequences of diseases for Europeans as they arrived in the New World, or soon afterwards. See *Born to Die*, 29ff.

4. In 1538, the crown was informed that many of the medicines taken to the New World arrived, or became, "corrupted" there. The crown ordered its officials in Tierra Firme to check the medicines and destroy those that were decayed. See Cédula Real a los oidores de Tierra Firme. 16 April 1538. Valladolid. AGI, Panamá, 235, L. 6, ff. 195v–196r.

5. When I began my research on the Hispaniola balsam in 1996 there were very few references to it in the secondary literature, and only an article on Antonio de Villasante by Ernesto Schäfer, "Antonio de Villasante, descubridor droguista en la isla Española," *Investigación y Progreso* 9, no. 1 (1935): 13–15. In 1996, I presented a paper at the Escuela Libre de Investigadores (Seville, Spain), and, with few changes, at the Consejo Superior de Investigaciones Científicas (Seville, Spain) which discussed the balsam case and its commercialization. Later Esteban Mira-Caballos published an article that discusses the Hispaniola balsam. See his article "La medicina indígena en la Española y su comercialización (1492–1550)," *Asclepio* 44 (1997): 185–198.

6. On this subject see Antonello Gerbi, *Nature in the New World* (Pittsburgh: University of Pittsburgh Press, 1985), and Raquel Alvarez-Peláez, *La Conquista de la Naturaleza Americana* (Madrid: Consejo Superior de Investigaciones Científias, 1993).

7. For the establishment of the Casa de la Contratación see the royal decree of 14 February 1503, AGI, Contratación, 5784, l.1, ff. 1v–2. See also Antonio de Herrera, *Historia General de los Hechos de los Castellanos en las Islas i Tierra Firme del Mar Oceano. Escrita por Antonio de Herrera Coronista (sic) Major de Su Magestad de las Indias y su Coronisata de Castilla*, ([Madrid: Imprenta Real, 1601–15]; Madrid, 1730), década I, p. 144; Joseph de Veitía Linage, *Norte de la Contratación de las Indias Occidentales* ([Seville, 1672], Buenos Aires: Publicaciones de la Comisión Argentina de Fomento Interamericano, 1945), 4–5; José Pulido-Rubio, *El Piloto Mayor de la Casa de la Contratación de Sevilla: Pilotos Mayores, Catedráticos de Cosmografía y Cosmógrafo* (Seville, 1950); David C. Goodman, *Power and Penury* (Cambridge: Cambridge University Press, 1988), pp. 74ff.; J. H. Parry, *The Spanish Seaborne Empire* (Berkeley and Los Angeles: University of California Press, 1990), 54f.; and Clarence Henry Haring, *Trade and Navigation between Spain and the Indies* (Cambridge, Mass.: Harvard University Press, 1918), chap. 2. The Casa de la Contratación awaits its modern historian. On the establishment of the Council of the Indies see Ernesto Schäfer, *El Consejo Real y Supremo de las Indias*, 2 vols. (Seville: M. Carmona, 1935) as well as his article, "El Origen del Consejo de Indias," *Investigación y Progreso* 7 (5 May 1933): 141–145. For an overview of the scientific activities of the Casa de la Contratación, the Council of the Indies, and the Royal Academy of Mathematics, see Ursula Lamb, "Cosmographers of Seville: Nautical Science and Social Experience," in *First Images of America: The Impact of the New World on the Old*, ed. Fredi Chiappelli (Berkeley and Los Angeles: University of California Press, 1976), vol. 2: 675–686.

8. See Columbus's development through his diaries in J. Cecil, *The Four Voyages of Cloumbus*, 2 vols. (New York: Dover, 1988). See also Valerie I. J. Flint, *The Imaginative Landscape of Christopher Columbus* (Princeton, N.J.: Princeton University Press, 1992); Stephen Greenblatt, *Marvelous Possessions* (Chicago: University of Chicago Press, 1991); and Gerbi, *Nature*.

9. See the letter of Dr. Chanca (1494) in Martín Fernández de Navarrete, *Colección de los viages y descubrimientos que hicieron por mar los Españoles desde fines del siglo XV con varios documentos inéditos concernientes a la historia de la Marina Castellana y de los Establecimientos Españoles en Indias* (Buenos Aires: Editorial Guarania, 1945); and the letter of Michele Cuneo (1495) in Samuel Eliot Morison, *Journals and Other Documents on the Life and Voyages of Christopher Columbus* (New York: Printed for the members of the Limited Editions Club, 1963), 209ff.

10. On this topic see John Law, "On the Methods of Long-distance Control: Vessels, Navigation, and the Portuguese Route to India," *Sociological Review Monograph* 32 (1986): 234–263; Steven J. Harris, "Confession-Building, Long-Distance Networks, and the Organization of Jesuit Science," *Early Science and Medicine* 1 (1996): 287–318 as well as his article "Long-distance Corporations, Big Science, and the Geography of Knowledge," *Configurations* 6 (1998): 269–304.

11. The name "Chamber of Knowledge" is my own characterization of the scientific aspects of the Casa de la Contratación. By Chamber of Knowledge I mean the offices and practices developed and institutionalized within the *Casa* for collecting and disseminating information about the New World, for training lay people (pilots) in the new navigational techniques, and for hiring professionals (cosmographers and pilots) for research and teaching activities. Haring calls it a "Hydrographic Bureau and School of Navigation, the earliest and most important in the history of modern Europe" (*Trade and Navigation*, 35).

12. Andrés Laguna, *Pedacio Dioscórides Anazarbeo, acerca de la materia medicinal, y de los venenos mortíferos. Traduzido de la lengua Griega en la vulgar Castellana, e illustrado con claras y substanciales Annotaciones, y con las figuras de unnúmeras plantas exquisitas y raras por el doctor . . . , Médico de Julio III, Pontífece Máximo* (Anvers, 1555), ff. 26ff. On the importance of balsam for sixteenth-century naturalists, see Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley and Los Angeles: University of California Press, 1994), 270ff.

13. Pero Tafur, *Andanças e viajes de Pero Tafur por diversas partes del mundo avidos (1435-1439)* (Madrid, 1874), 85–86.

14. Ibid., 575 n.: *bálsamo*

15. Cédula Real del Rey don Carlos. January 29, 1525. Madrid. AGI, Contratación, 5787, N. 1, L. 1. ff. 33–34v.

16. Ernesto Schäfer, "Antonio de Villasante," 13. Villasante's name appears in a document signed in Santo Domingo in February 1515. In this document, Villasante was proposed as a witness (together with other residents) to answer questions about Rodrigo de Albuquerque's activities on the island in 1514. AGI. Justicia 1003, transcribed in Luis Arranz-Márquez, *Repartimiento y Encomiendas en la Isla Española (El Repartimiento de Albuquerque de 1514),* (Santo Domingo: Ediciones Fundación García Arévalo, 1991).

17. Arranz-Márquez, *Repartimiento*, 560. On the Tainos, see Irving Rouse, *The Tainos: Rise and Decline of the People Who Greeted Columbus* (New Haven, Conn., Yale University Press, 1992). Cook suggests that the Taino population around 1492 might have been half a million, by 1518–19 the numbers had fallen to around eighteen thousand and by 1542 the native population was less than two thousand. Villasante's information came from a group that was disappearing from the earth. See Cook, *Born to Die*, 23–24.

18. Provisión Real proponiendo un asiento con Antonio de Villasante sujeta a la presentación de un reporte de Villasante sobre el bálsamo y otras drogas. 4 April 1528. Madrid. AGI, Indiferente, 421, L. 13, ff. 85r–86v.

19. Fernández de Oviedo comments that this balsam is not the real balsam but something different that Villasante called balsam. Oviedo also says that Villasante either learned the secret of balsam from his *cacica* wife or from an Italian physician who went to the Indies in 1515 and died there. See Gonzalo Fernández de Oviedo y Valdés, *Historia General y Natural de las Indias*, 5 vols. (Madrid: Biblioteca de Autores Españoles, 1959), vol. 2: 11.

20. Relación de Antonio de Villasante, n/d, but it was probably presented in mid-1528. AGI, Indiferente, 857. On 4 April 1528 the king ordered Villasante to present a report before the council. By 14 June 1528 he had already submitted his report, see Indiferente, 421, L. 13, ff. 213v–214r. Ernst Schäfer thinks that this document dates from around 1526, for, according to him, Villasante was in Spain in 1525, see Ernst Schäfer, "Antonio de Villasante," 14. Perhaps Villasante was in Spain in 1525 or 1526 and at that time sought support for his project. The call number given by Schäfer for this Villasante's report, Indiferente, 856, is a mistake; it is Indiferente, 857; see also a document in *Colección de documentos inéditos relativos al descubrimiento, conquista y colonización de las posesiones españolas en América y Oceanía,* (Liechtenstein: Kraus Reprint, 1966), series 2, 14: 31.

21. See note 17.

22. Villasante, Indiferente, 857.

23. Ibid.

24. The Spaniards also took spices and medicines for agricultural and commercial purposes to the New World. Thus, Don Francisco de Mendoza, son of the first Mexican viceroy, signed in 1558 two capitulations with the princess Doña Juana (approved by Philip II in 1559) to cultivate ginger, sandalwood and pepper, cinnamon, and clover. See María Justina Sarabia-Viejo, *Don Luis de Velasco, virrey de Nueva España (1550–1564)* (Seville: Escuela de Estudios Hispano-Americanos, 1978), 403–405. The Council of the Indies considered this project unfeasible. See Consulta del Consejo. 21 March 1559. Valladolid. AGI, Indiferente, 738, N. 47.

25. Villasante, Indiferente, 857: "La maña que hasta agora yo he tenydo en el sacar del licor con otros cosas de estos arvoles asy lo? que con un cuchillo cortados los rramos destos arboles con su hoja y grano y con la mano arrancaba los granos y tambien la hojarada cosa por sy y tomaba los rramos asy mondos y tambien tomava de la corteza de lo grueso del arvol hacia el tronco y lo desmenuzava y . . . taba? y lo majava encima de unas piedras o losas con otras piedras

o madero despues de picado con cuchillo y asy majado lo ponya en unas vasijas de barro de? m . . . ? de barreno?nes? o labrillos? y . . . ? calentaba en un caldero con una cantidad de agua competente y la echava en el dicho barreno? y desde a un poce despues de enpapado y enbevido en el agua lo apretavba en un tornyllo de madera y sacaba dello todo el çumo y . . . d? que tenyz y lo colava y colado lo ponya en un caldero pequeno y despues tomaba otro caldero grande lleno de ceniza hasta la mytad del . . . ?/ y dentro de aquel caldero de ceniza ponya y asentaba el otro caldero pequeño con el dicho licor del balsamo colado y ponya fuego debajo del caldero de la ceniza de maña que el calor dela ceniza consumyese el agua que estaba en dicho licor hasta tanto que se espesava y tornaba del color y maña que yo ho he tenydo y entregado a su mag/ . . . ".

26. Villasante, Indiferente, 857.

27. Ibid.: explained that balsam was "en la verdad provechoso asi en las Indias donde lo experimente muchas veces como algunas en estos reinos en sevilla y en la corte y pues para estas enfermedades que he dicho ha parecido por experiencia ser provechoso adelante podra parecer por experiencias o por relacion de los medicos si aprovechara a otras cosas y tambien ellos diran la forma que se podra tener para mas perfeccion del dicho licor y balsamo y otras cosas del dicho arbol."

28. Garciperez Morales, *Tratado del Bálsamo y de sus utilidades para las enfermedades del cuerpo humano. Compuesto por el Doctor . . . catedrático de prima en el colegio de Sancta Maria de Jesus de la ciudad de Sevilla. Dirigido al yllustrissimo señor don Pedro Giron Duque y Conde de Ureña* (Seville, 1530), ff. 2r.

29. Nicolás Monardes was a physician and entrepreneur very interested in the natural resources of the New World. His father, Niculoso de Monardis was a Genovese bookseller established in Seville. It is unclear when Nicolás Monardes was born; he died in 1589. Monardes obtained his B.A. in art and philosophy in 1530 and a B.A. in medicine at the Universidad Complutense in 1533. In 1547 he obtained the *licenciatura* and doctor's degree from the Colegio-Universidad de Santa María de Jesús de Sevilla. Monardes's medical practice in Seville was very successful. He worked with the doctor Garciperez Morales and, in 1537, Monardes became Morales's son-in-law when he married Morales's daughter Catalina. Monardes was also very successful in his commercial activity in the Indies. He obtained many plants and herbs for his medical practice and his garden through his commercial contacts in the Indies. See Juan Jiménez-Castellanos y Calvo-Rubio, prologue to *Historia medicinal de las cosas que se traen de nuestras Indias Occidentales que sirven en medicina . . . por Nicolás Monardes* (Seville: Padilla Libros, 1988), v to xi. See also Nicolás Monardes, *[Primera y Segunda y Tercera partes de la] Historia Medicinal de las cosas que se traen de nuestras Indias Occidentales que sirven en Medicina* ([Facsimile edition, 1574] Seville: Padilla Libros, 1988); for a discussion of Monardes's work see José M. López Piñero, "Las 'Nuevas Medicinas' Americanas en la Obra (1565–1574) de Nicolás Monardes," *Asclepio* 42, no. 1 (1990): 3–67. The work of Monardes was translated into English (Nicolás Monardes, *Ioyfull Newes Out of the Newe Founde Worlde* [London, 1577]) as well into French, Latin, and Italian.

30. Provisión Real a Antonio de Villasante. 20 April 1528. AGI, Indiferente, 421, L. 13, ff. 110r–111r.

31. Ibid. 22 April 1528. AGI, Indiferente, 421, L. 13, ff. 111r–112r; Real Provisión a Antonio de Villasante. 14 June 1528. AGI, Indiferente, 421, L. 13, ff. 213v–214r.

32. Cédula Real a los oficiales de la Casa de la Contratación. 16 December 1513. Madrid. AGI, Panamá, 233, L. 1, f. 126r.

33. Ibid.

34. Cédula Real al licenciado Rodrigo Figueroa, juez de residencia de la isla Española. 26 July 1519. Barcelona. AGI, Indiferente, 420, L. 8, f. 97v.

35. Cédula Real a los oficiales de la Española. 14 September 1526. Granada. AGI, Indiferente, 421, L. 11, ff. 202v–203r.

36. Carta del licenciado Barreda al rey Carlos V. 26 October 1528. Santo Domingo de la Española. AGI, Patronato, 174, R. 43.

37. Carta de Barreda, AGI, Patronato, 174

38. See Alison Sandman's contribution to this volume, "Mirroring the World: Sea Charts, Navigation, and Territorial Claims in Sixteenth-Century Spain"; and Ursula Lamb's fascinating articles, "Science by Litigation: A Cosmographic Feud," *Terrae Incognitae* 1 (1969): 40–57, and "The Spanish Cosmographic Juntas of the Sixteenth Century," *Terrae Incognitae* 6 (1974): 51–64.

39. Carta de Barreda, AGI, Patronato, 174: "la virtud mas principal que se halla en el dicho licor/ es restreñir la sangre en las llagas frescas sobre ellas aplicado/ y dado por la boca el fluxo de sangre por abaxo/ dest avirtud agora sc opilativa que sua viscositatc aut g?oficie inplendo venari orificia rectineat sanguyneus/ agora sea constrictiva que sua frigiditate /r? stiticitate? constringat venas. digo que entanta manera aprieta que puesto sin ligadura parece el miembro estar atado// pues donde sc vido ni cn quc libros sc hallo tencr cl balssamo esta virtud antes dc todo en todo contraria en lo qual por ser muy manifiesto dexo de ser prolixo//."

40. Laguna, *Dioscórides*, 26–27.

41. See Andrés Laguna, *Pedacio Dioscórides Anazarbeo, acerca de la materia medicinal, y de los venenos mortíferos. Traduzido de la lengua Griega en la vulgar Castellana, e illustrado con claras y substanciales Annotaciones, y con las figuras de unnúmeras plantas exquisitas y raras por el doctor . . . , Médico de Julio III, Pontífece Máximo* (Anvers, 1555), 26 and 27; Nicolás Bautista Monardes, *Historia Medicinal,* ff. 9ff; Conrad Gesner, *Evonymus C. Gesneri Medici de Remedis secretis, Liber Physicus, Medicus & partim etiam Chymicus, & Oeconomicus in vinorum diversi saporis apparatu, Medicis & Pharmacopolis omnibus praecipue necessarius, nunc primum in lucem editus,* n/p, n/d [This seems to be the edition from Zurich, c. 1565; for the date and place see Klaus Wagner, *Catálogo abreviado de las obras impresas del siglo XVI de la Biblioteca Universitaria de Sevilla* (Seville: Universidad de Sevilla, 1988)], ff. 131r–v; Pedrarias de Benavides, *Secretos de Chirurgia, especial de las enfermedades de Morbo galico y Lamparones y Mirrarchia, y asimismo la manera como se curan los Indios de llagas y heridas y otras passiones en las Indias, muy util y provechoso para en España y otros muchos secretos de chirurgia hasta agora no escritos* (Valladolid, 1567), ff. 30v–31r.

42. Carta de Barreda, AGI, Patronato, 174.

43. Ibid.

44. Cédula Real de la Reina a las justicias de Sus reinos. 5 April 1530. Madrid. AGI, Indiferente, 422, L. 14, f. 67v.

45. Ibid.

46. Ibid., 67v–68r.

47. Ibid., f. 68r.

48. Cédula Real a los visitadores del Hospital del Cardinal de la ciudad de Toledo. 5 April 1530. Madrid. AGI, Indiferente, 422, L. 14, f. 72v.

49. Cédula Real a los visitadores de varios hospitales. 5 April 1530. Madrid. AGI, Indiferente, 422, L. 14, f. 72v.

50. Cédula Real al bachiller Andrés de Jodar médico, vecino de Baeza. 5 April 1530. Madrid. AGI, Indiferente, 422, L. 14, ff. 73r–74v.

51. Cédula Real a varios médicos y cirujanos. 5 April 1530. Madrid. AGI, Indiferente, 422, L. 14, ff. 73r–74v.

52. Cédula Real a Pedro Benito de Basniana y Franco Leardo para que puedan subir los salarios asignados a los médicos que contribuyen a la propaganda del bálsamo. 12 July 1530. Madrid. AGI, Indiferente, 422, L. 14, ff. 102r–103r.

53. Cédula Real a los oficiales de Cuéllar. 16 October 1532. Madrid. AGI, Indiferente, 422, L. 15, ff. 197v–198r.

54. Ibid.; Cédula Real a Diego de la Haya para que pague a Melchor de Angulo. 27 November 1532. Madrid. AGI, Indiferente, 422, L. 15, f. 199v.

55. Cédula Real a Juan de Vargas para que venga a la corte. 21 November 1532. Madrid. AGI, Indiferente, 422, L. 15, f. 199r.; and Mandamiento a Diego de la Haya para que pague a Juan de Vargas por haber estado en la corte. 27 February 1533. Madrid. AGI, Indiferente, 422, L. 15, f. 199r.

56. Mandamiento a Diego de la Haya para que pague a Juan de Vargas por haber estado en la corte. 27 February 1533. Madrid. AGI, Indiferente, 422, L. 15, f. 199r.; Cédula Real a Diego de la Haya para que pague cierta suma a Juan de Vargas. 3 October 1533. Monzón. AGI, Indiferente, 422, L. 16, f. 43v., Real Cédula a Juan de Vargas. 18 April 1534. Toledo. AGI, Indiferente, 422, L. 16, f. 75v.

57. Cédula Real a los alcaldes ordinarios de la villa de Amusco. 23 May 1539. Toledo. AGI, Indiferente, 423, L. 19, ff.247–248.

58. Monardes, *Historia*, ff. 9r.

59. See Flint, *Christopher Columbus*; Richard H. Grove, *Green Imperialism* (Cambridge: Cambridge University Press, 1995); Steven Greenblatt, *Marvelous Possessions*; Gerbi, *Nature*; and John H. Elliott, *The Old World and the New* (Cambridge: Cambridge University Press, 1970).

60. On this topic see Grove, *Green Imperialism,* 32ff.

61. In 1564 and 1565, the botanist Carolus Clusius (1526–1609) visited Spanish botanical gardens, such as Simon de Tovar's well-known garden. Later he would receive samples of plants and curiosities from Spain for his books. For Clusius's visit to Tovar's garden, see Carolus Clusius, *Rariorum Plantarum Historia* (Antwerp, 1601), 50: 2. 173. For his contacts in Spain, see Asso, *Hispaniiensium atque Exterorum Epistolae cum praefatione et notis Ignatii de Asso* (1793), 53–70. The physician Nardo Antonio Recchi brought the work of Dr. Francisco Hernández on American plants and animals to Italy in the late sixteenth century. Recchi's summary of Hernández's work was published by the Academia dei Linceii between 1630 and 1651. See Raquel Alvarez-Peláez, "La obra de Hernández y su recuperación ilustrada," in *La Real Expedición Botánica a Nueva España, 1787–1803* (Madrid: Consejo Superias de Investiganes Científicas, 1987), 156 n. 1, as well as her article, "La historia natural en la segunda mitad del siglo XVI: Hernández, Recchi y las relaciones de Indias," in *Nouveau Monde et Renouveau de L'Histoire Naturelle,* Vol. 3, ed. Marie-Cécile Bénassy et al. (Paris: Presses de la Sorbonne Nouvelle, 1994).

Merchants and Marvels

Hans Jacob Fugger and the Origins of the Wunderkammer

MARK A. MEADOW

TRADE, TRAVEL, AND THE PROCUREMENT OF CURIOUS OBJECTS

In the cultural world of sixteenth-century Europe, few institutions offer a more compelling venue to study the intersection of art, nature, science, and economics than the *Kunst-* and *Wunderkammern* (commonly in English: curiosity cabinets) of such figures as the Wittelsbach Duke Albrecht V of Bavaria or the Habsburg Holy Roman Emperor Rudolf II of Prague.[1] These *Wunderkammern* served many functions within the great courts of transalpine Europe, being not only instruments of diplomacy and display, but also pragmatic tools of economic statecraft, repositories of ready funds for unexpected wars and disasters, sites of cultural and technological production, and active, functional, and practical laboratories for a variety of crafts and disciplines.

In order to think about the role of trade objects in these collections, let me begin by posing a scenario and a question. In these great collections of Albrecht V, Rudolf II and others, visitors encountered a vast and marvelous range of *naturalia* (natural objects) from across the globe: narwhal tusks from near the Arctic, camel bezoars from the East, ivory and ostrich eggs from Africa, birds and featherwork from the New World. *Artificialia* (works of human craftsmanship) were also present in various forms, including Limousin enamel, majolica pottery, and Venetian glass. Other human artifacts came from well beyond the European world: Indian and Turkish carpets, Tunisian textiles, carved African ivory, South American and Mexican gold and featherwork, Syrian metalwork, shoes from Lapland, and kayaks from Greenland, to name but a few. The question I want to raise is a simple one: How did these varied and heterogeneous things make their way to the Munichs or Pragues of the sixteenth century?

The answer is, of course, much more complicated than the question. In this essay I will address one part of that answer, speaking to the crucial role

played by the extraordinarily wealthy and powerful merchant-banking families—such as the Fuggers, Welsers, or Medicis, but especially the first—in bringing these sorts of objects and materials from their points of origin to the courts and collections of Europe. In particular, I will discuss one member of the Fugger family, Hans Jacob Fugger, 1516–75, and the part he played in the material and conceptual formation of the *Wunderkammer*.

We know, for example, of several instances in which the Fuggers were involved in the procurement of particular objects, as for example two ivory caskets they secured from Ceylon via Lisbon, and provided for Albrecht V in 1566.[2] Ivory importation as a raw material was a substantial business in itself, with the Fugger offices in Antwerp making a contract in 1548 to exchange 6,750 hundredweight of brass rings (the family controlled enormous copper mining resources) for large shipments of ivory from Benin, to be crafted into fine objects for resale.[3] Max Fugger, in the 1560s, was very active in procuring gemstones, finished necklaces, and other pieces of jewelry for Albrecht V, both for his own collections and as gifts to figures such as King Philip II of Spain.[4] In the latter part of the century, via Antwerp and through its connections in India, the House of Fugger imported monkeys, parrots, peacocks, wildcats, and other live animals; orange trees, almond trees, rosemary bushes, and other live botanicals; camphor, pearls, leopard skins, indigo, gemstones, and similar natural by-products.[5] These examples of *naturalia*, living or not, ended up in the Fuggers' own collections as well as those of their patrons. Craftsman were employed to work on the raw materials, transforming them into finished products to be sold or given to wealthy and noble clients. In a similar vein, the Fuggers may have been the means by which the merchant-scholar Philipp Hainhofer gained access to South American objects for his own *Kunstkammer*, again through the Fugger offices in Portugal.[6]

The question of how the Fuggers, or other firms like theirs, contributed to the procurement of exotica for these collections, and the implications thereof, is not a trivial one. The objects collected in *Wunderkammern*, especially the exotica, flooded in from throughout the known world, and even at times from beyond it. In an era before the establishment of disciplines such as zoology or botany, ethnography or anthropology, the stories these objects told derived in no small part from the biographies they acquired moving from hand to hand. Their original contexts, uses, and narratives were filtered through the numerous people involved at each stage of their journey. The Fuggers and their representatives, and those of other families, were critical participants in the life histories of these objects. Furthermore, the diverse interests of the Fuggers themselves inevitably affected the procurement process. Certainly business concerns were paramount, and an eye was always kept on the bottom line. But the Fuggers, by the time of Hans Jacob,

were intimates of dukes, kings, and emperors, serving at times as courtiers, advisors, financial consultants, and bankers. They were humanists and scholars, trained at the finest universities in Europe. They were also avid collectors of books, ancient coins, exotica, musical and mathematical instruments, fully conversant with the thematic collecting interests of their clients. And perhaps most important, they combined their intellectual and acquisitory pursuits with the practical matters of running a business and communications empire. The sheer vastness of their wealth, of their land holdings, and of their power made them coequals in many ways with the nobility they served.

The Fugger's own collecting practices are central to understanding their role in relation to princely collections. In this period, collecting by its very nature was a communal activity. Princes, scholars, merchants, or apothecaries assembled their collections through complex systems of exchange, gift giving, commerce, patronage, and other forms of social and financial intercourse. To some extent, the activity of collecting provided a social nexus, in which noble, scholar, tradesman, and even craftsman could participate in the same realm. By participating in this system as collectors as well as purveyors, the Fuggers and other such families placed themselves within an intellectual and social milieu that furthered much more than their business goals. As a result, at least in part, the Fuggers gained the rank of minor nobility, status as legitimate scholars and humanists, and a role as patrons of the arts, scholarship, and technology.

Lorraine Daston and Ken Arnold have both stressed the importance of travel in relation to curiosity cabinets. As Daston has written, "Travel was the alpha and omega of collecting, being both the source of the bulk of the objects—voyages of exploration and subsequent trade with the newly discovered lands created a steady flow of exotica—and the occasion for inspecting them in Amsterdam, Oxford, Venice, Paris, Augsburg, Uppsala, or wherever the curious and peripatetic tourist might land."[7] Arnold discusses the close affinities between travel and collecting, noting that "the relationship between the two was precisely reciprocal: one traveled in order to collect, but also one collected in order to travel."[8] Indeed, as Arnold notes, viewing a curiosity cabinet was itself a microcosmic form of travel, "through a world brought back and reassembled in a cabinet."[9] I would like to deviate slightly from the general question of travel and instead consider the importance of trade in the formation of the cabinets. The two issues are closely intertwined, but it is especially instructive here to consider the commercial aspects of travel. Intellectual history often places trade, and the commercial world in general, in the silent shadows when considering perceptions and models of the cosmos.[10] We can use the Fuggers and *Wunderkammern* to bring to light some of the implications of their close relationship.

In particular, I will discuss the relationship of sixteenth-century commercial networks to both the material and the conceptual formation of micro-

cosmic collections north of the Alps. In the course of the larger research project here outlined, I want to situate this commercial world within the broader framework of similar networks, such as the travel and epistolary networks of the humanists; the closely related networks joining together universities and their faculty and students; and the tightly woven fabric of Europe's courts, stitched together through intermarriage and political alliances.

These various skeins of interrelationship are themselves interdependent and interwoven. Hans Jacob Fugger stands as an excellent example of this, bringing together in a single individual the worlds of the university, humanism, the courts, and commerce. As we will see in greater detail below, Fugger plays not one, but several significant roles in the founding moments of the *Wunderkammer*: he was himself a patron, scholar, and collector, but also, following a financial reversal, he worked as a librarian and procurer of books and objects for one of the very earliest of the collections under consideration, that of Albrecht V, elector of Bavaria.

I have been pushing very hard at the metaphors of threads and cloth in order to allow myself to bring in an enlightening fable from Italo Calvino. In his *Invisible Cities*, he includes, under the rubric of "trading cities," a place called Ersilia. In this city,

> to establish the relationships that sustain the city's life, the inhabitants stretch strings from the corners of the houses, white or black or gray or black-and-white according to whether they mark a relationship of blood, of trade, authority, agency. When the strings become so numerous that you can no longer pass among them, the inhabitants leave: the houses are dismantled; only the strings and their supports remain.[11]

The web of many-colored strings that Calvino describes serves as a map of relationships, and those relationships are themselves markers for what we would now call data flow. Reconstructing such threads may therefore serve as a critical analytical tool. We might well say that the houses of the sixteenth century have been dismantled, and certainly the inhabitants of the period have long since departed. But we can still make out the tapestry of social and cultural life that remains in the various strands of relationship. While calling attention to one color of string, the gold and silver strings of commerce, I will also be touching on many of the others. Indeed, in the world of the curiosity cabinet, as in any other place or period, the strands of blood, trade, authority, and agency were all present, and were all interdependent. To touch any of these strands is to set all the others in sympathetic vibration.

The essay that follows, I should note, is more a blueprint for an ongoing research project than the finished results of one. Tracing any one of the social, intellectual, economic, or political networks of the period is itself a

daunting task. Examining all of these, and their points of intersection, is Herculean. Nonetheless, if we are truly to understand the conceptual matrix in which the *Wunderkammer* functioned, this line of research must be pursued. The larger study that will develop from this report is a component of a major research initiative undertaken within the University of California. Called "Microcosms: Objects of Knowledge," this broader project is examining the history, functions, and future of material collections in the contemporary university.[12] As is appropriate for a place that calls itself a university, these vast holdings are universal in scope, and when examined holistically bear a surprisingly close resemblance to the range of objects found in a *Wunderkammer*. The Microcosms Project considers these collections, and the university itself, from an historical perspective, turning especially to the sixteenth century, and the *Wunderkammer*, as one point of origin for the modern university and its collections. As we are all aware at the beginning of the twenty-first century, the university is itself intimately bound into a vast range of networks, including those of commerce. Nor is it any coincidence that I have chosen to emphasize metaphors of threads, networks, and skeins, considering how intimately bound the worlds of information and trade have become in the digital community that we have come habitually to call the "net" or the "web."

THE HOUSE OF FUGGER

Before turning to our particular Fugger, Hans Jacob, I will briefly sketch some of the family history. The Fuggers arrived in Augsburg in 1367 in the person of one Hans Fugger, a clothmaker who appears to have founded the family business by importing his own raw materials, rather than relying upon local merchants for them. The firm developed slowly in the next generation, first through Hans's sons Andreas and Jacob I, and then through Jacob's capable widow, Barbara Bäsinger, who ran the business until her children were of age to assume control themselves. From the widow Fugger, the business passed on first to her eldest and youngest sons, Ulrich and Georg. Ulrich and Georg first established a Fugger presence in the German merchants' trade building in Venice, the *Fondaco dei Tedeschi* (German business house).

Finally in 1485, the middle child, Jacob II, who was later to become known as Jacob the Rich, entered the management of the business by taking charge of the Innsbruck office and aggressively pursuing mining opportunities in the Tyrol. Jacob II had trained in bookkeeping and other aspects of business management at the Venetian *Fondaco* since 1478. Ulrich, Georg, and Jacob II formed a trade partnership in 1494, in which the business theo-

retically was equally shared among them. Although he did not formally become the director of the company until Ulrich's death in 1510, it was Jacob II who contributed most to creating the enormous fortune that catapulted the Fuggers into the center of sixteenth-century European commerce and political power. Jacob II, surviving his two brothers and desiring to extend his control over the firm, later changed the partnership model of governance to that of a single, autocratic director.

Jacob's basic strategy was a very simple but highly effective one. He lent money to the ruling houses of Europe at very high rates of interest, with the loans secured against the income-generating resources that such dukes, princes, kings, popes, and emperors could provide: silver and copper mines, agricultural communities and land, and so forth. A frequent formula employed by Jacob II was to lend large sums of money on a long term basis, with the stipulation that until the loan and its interest were repaid, the production of a particular site, usually a mine, went directly to the Fuggers. In certain instances, should the loan not be repaid in the allotted time, the secured property reverted permanently to the Fuggers. In this way, massive amounts of capital were quickly acquired, together with more stable sources of future earnings in the form of real property. Jacob built especially upon the relations his brother Ulrich had already established with the Habsburgs; the Fuggers, for instance, were one of the main, perhaps even the single most crucial, resource in assuring the election of Charles V as holy Roman emperor in 1519. This same connection to the Habsburgs eventually led to the fading of the Fugger family star, as improperly secured loans and even private family capital went to sustain Charles and his son Philip II, king of Spain, only to result in Habsburg defaults in 1557, 1574, 1575, and 1596. The first of these financial crises was among the main reasons why Hans Jacob Fugger was eventually forced out of the family business and into the service of Albrecht of Bavaria and his collections, thus indirectly setting into motion the story with which we are concerned.

From the time of Jacob I on, as the business grew increasingly large and complex, the Fuggers followed a strategic program of education for their offspring to ensure that the successors to the firm were properly prepared in languages, mathematics, law, and the humanist cultural background that would allow them to converse with the ruling elite. At first this involved sending them to the Fugger outposts in Europe, initially, as in the case of the young Jacob II, to the *Fondaco dei Tedeschi* in Venice, but eventually young Fuggers set out on a grand tour throughout the continent. A bit later, in the time of Hans Jacob's youth, this period of educational preparation also specifically included university education. Here is one of the key points where, for the Fuggers and other such families, the worlds of commerce and humanism intersected.

A business of the scale of the Fuggers', spread across all of Europe and into the vast lands beyond, necessitated efficient lines of communication. The Fuggers operated what are called "factories," that is, places of business run by individuals authorized to conduct business for the family, the "factors," throughout Europe and beyond. Among the places in which the Fuggers had offices were Lisbon, Seville, Madrid, Saragossa, the Tyrol, Vienna, Innsbruck, Munich, Leipzig, Nuremberg, Frankfurt, Cologne, Antwerp, Amsterdam, Paris, Lyon, Strasbourg, London, Helsingör, Malmö, Danzig, Riga, Narva, Poznan, Warsaw, Krácow, Ofen, Breslau, Pest, Venice, Rome, Florence, and the Levant. Through these sites, and many, many others too numerous to list, the Fuggers acted as brokers for trade flowing throughout the known world. In fact, Fugger factors were located in virtually every community of any economic significance in Europe, which means down to locales of only a few thousand residents, with (largely for political reasons) a somewhat more modest presence in France and Spain. But the Fugger mercantile operations were by no means limited to Europe. The Fuggers were involved in all areas of international trade, including between the New World and Europe, where they had offices in Santo Domingo, the Yucatan peninsula, Brazil, and elsewhere.[13] In 1531, the same year that Pissaro reached Peru, the Fuggers were granted a contract to colonize and economically exploit the western coast of Latin America from the southernmost point of Pizzaro's dominion to the tip of Tierra del Fuego.[14] They financed commercial ventures in India and Ceylon through Lisbon, traded in goods and slaves from Africa, and brokered merchandise from as far away as East Asia.

All of the Fugger outposts were expected to stay in constant touch with the home office, and, where necessary, with each other. This led to the creation of a very efficient system of communication, with letters flowing constantly in and out of the home office; paralleling a similarly efficient mechanism for transporting goods in bulk.[15] Primarily from library purchases, the facet of Fugger collecting that has been most thoroughly researched, we know that acquisitions were made along these lines of communication.[16] As business letters were sent out from Augsburg, they would include requests to secure one or another book or object, which in turn would accompany the reply, bringing the desired purchase safely home in very short order.

If we think only of two of the major Fugger factories, those in Venice and Antwerp, we can begin to understand something about the position the Fuggers were in to tap into the fullest range of natural objects and human artifacts as they traveled along the veins and arteries of the early modern commercial world. Venice remained the single most important port in southern Europe, with particular connections to Africa, the Middle East, and on into Asia. Antwerp played a similar role in the North, being the cen-

ter of commerce with Scandinavia, the Baltic, England, the Iberian peninsula, and various Spanish and Portuguese territories in Africa and the New World. The Fuggers quickly came to dominant positions in both of these markets, and between the two had access to virtually any materials or goods that could be commercially transacted. This is the beginning of the answer to the question I posed at the start of this chapter; important research remains to be done on the specific relationship between the formation of any given princely collection and the financial / mercantile web with which that court was linked. If we take a *Kunst-* or *Wunderkammer* to be a representation of the world, a microcosm, then the accessibility of particular markets, trade routes, and therefore particular objects will have a direct bearing on the model of the world thus created.

HANS JACOB FUGGER

As I turn to Hans Jacob Fugger, I also shift to a different aspect of the question. That is, however important the biographies of objects are to their significance within a collection, and however central the Fuggers are to the formation of those biographies, in the person of Hans Jacob we come to a figure who had a direct bearing upon the activity of collecting as a necessary part of sixteenth-century statecraft and also upon the ordering systems employed in these collections.

Hans Jacob was born in December 1516, the son of Raimund Fugger and nephew of Anton, who was then in charge of the company.[17] Anton and Raimund were the children of Georg Fugger, the brother of Jacob II, who had died childless. Raimund was a renowned collector of antiquities and encouraged his son in similar directions. Hans Jacob had an unusually thorough education, with studies in Germany, Italy, France, Spain, and the Netherlands. His education was primarily classical and linguistic—he was apparently fluent in Latin, Italian, French, Spanish, Polish, Hungarian, and, in all likelihood, Dutch as well.[18] Among those with whom he studied were Wolfgang Bosch, later tutor to Albrecht V of Bavaria, and Johannes Secundus, later court humanist to Margaret of Austria and Philip of Burgundy.[19]

His advanced studies, first with Viglius Zwichem van Aytta, were oriented toward law.[20] He followed Viglius from Dôle to Bourges. While in Bourges he also studied with Andreas Alciati, and appears already to have become a bibliophile, lending Alciati his own copy of Titus Livius.[21] From Bourges he moved to the university in Padua, and then to Bologna by 1534, where he was named syndic of the German Trading Nation while still a student.

It is worth briefly looking at some of Hans Jacob's fellow students, who make a very impressive list. These include such humanist scholars as

Hieronymus Wolf, translator of Demosthenes; Sigmund Gelenius, translator of Josephus; and Roger Ascham, tutor to Elizabeth I of England.[22] In Bologna, Hans Jacob counted among his fellow students Alessandro Farnese, duke of Parma, governor general of the Netherlands, cardinal, and patron of the arts, and someone who was later to name Fugger his own "patrone"; Christopher Madruzzo, later bishop of Trient and Brixen, cardinal, and governor of Milan; Stanislaus Hosius, later cardinal and bishop of Augsburg; Otto Truchsess von Waldberg, also a future bishop of Augsburg; and Wiguleius Hund, later chancellor to the court of Bavaria.[23]

Hans Jacob Fugger was an author in his own right, drafting a history of his own family in 1541–45 and a history of the Habsburgs in 1555, which itself was a sort of collection, containing scores of portraits, images of places, genealogies, images of monuments, insignia, and thousands of coats of arms.[24] This assemblage of images and charts, in fact, corresponds very closely to the first of five classes in Samuel Quiccheberg's *Inscriptiones vel tituli Theatri amplissimi* (Inscriptions or headings of the most complete theater), a treatise on collecting and an organizational plan for Albrecht V's collections, and the earliest known treatise on museums.[25] Hans Jacob was furthermore a prolific patron of scholarship: Maasen lists more than sixty works dedicated to him, including Sigismund Gelenius's work on Flavius Josephus, Conrad Gessner's work on libraries and ordering systems, Jacopo Strada's scholarship on antiquities, Panvinius's history of the church and four works of Hieronymus Wolf.[26]

In 1535, Hans Jacob's father died, and he was summoned back to Augsburg by his uncle Anton to assume his position in the firm. While Hans Jacob was contractually given the equivalent of second-in-command of the family firm, Anton decided he was still not quite ready to take up the reins. So Hans Jacob was sent on a second tour, now specifically oriented toward familiarizing him with the business. Beginning with an extended stay in Antwerp, he traveled very widely among the Fugger factories in Europe.

Before his return to Augsburg, Hans Jacob entered service in the court of the Habsburg Ferdinand I, then king of Bohemia, brother to Holy Roman Emperor Charles V, and from 1556 emperor in his own right. While at Ferdinand's court, Hans Jacob served as tutor to Ferdinand's children, including Maximilian, holy Roman emperor following his father's death in 1564, and Archduke Charles. These figures loom large in the history of the *Wunderkammer*. Ferdinand is traditionally credited with founding the Habsburg *Kunstkammer*, with a particular interest in mechanical devices such as clocks and in antiquities and coins. Maximilian II continued his father's interests in collecting, especially antiquities and coins, but also artifacts of natural history. He later hired Jacopo Strada as architect of his collections, both conceptually and literally, as Strada designed the first Habsburg buildings devoted to the

family collections. The more famous collections of Maximilian's son Rudolf II built upon these foundations. The young Hans Jacob was introduced to more than just princes and princely collections while in Ferdinand's service; he also met his first wife, Ursula von Harrach. On 21 June 1540 the couple was wed, with the chief steward of Charles V's court in attendance.[27]

Fugger's return to Augsburg in 1540 heralded a lengthy period of involvement in politics and government, which included membership in different parts of the Augsburg city councils, and a stint as a mayor. His connections with the Habsburgs were exploited by the city during the religious troubles, with Hans Jacob being sent out on more than one occasion to mollify Cardinal Granvelle or the emperor himself.[28] Cardinal Granvelle and Emperor Charles V both were later houseguests of Hans Jacob while visiting Augsburg. After having attended at least two Reichstäge, Hans Jacob reached the pinnacle of his political career in 1549, when he was named imperial councilor by Charles V. At some point during this period, Hans Jacob also developed very close ties to Albrecht of Bavaria, indicated by records of Albrecht serving as godfather to some of Hans Jacob's twenty-one children.

In 1560, Anton died, leaving the business in the hands of Hans Jacob and his brothers. Anton, largely through circumstances beyond his control—the Habsburg financial crises mentioned earlier—left the business in comparatively bad shape. Things were not to improve under Hans Jacob, who by 1565 found himself personally bankrupt and the family fortune in not much better shape. Hans Jacob did not even have enough funds to cover his own tax debts, despite selling off most of own possessions. His friendship with Albrecht here paid off, when the latter personally extended him the money required to stave off complete disaster. Albrecht mediated negotiations between Hans Jacob and the rest of the family, which resulted in a return of the business to Anton's own children and Hans Jacob's permanent removal from the firm. One of the terms of the agreement appears to have been that Hans Jacob enter the service of Albrecht as court librarian, here returning to his earlier and perhaps more temperamentally suitable profession as humanist and scholar.[29]

Serving as a librarian must have suited Hans Jacob well. Even before his time, the Fugger family library was quite famous, but he had turned it into a collection nearly without equal. The Fugger library ranged from the latest vernacular books off the presses of all Europe, and a very comprehensive set of classical texts, to medieval, Byzantine, and even Syrian manuscripts.[30] In his heyday, Hans Jacob had hired as librarians and curators such individuals as Hieronymus Wolf;[31] Jacopo Strada, who may have had his first significant employment from Fugger;[32] and Samuel Quiccheberg, who would move into Albrecht's service at the same time that his former employer did and would write the *Inscriptiones vel tituli* there in 1565.[33]

Given the later activities and careers of Strada and Quiccheberg, we must seriously consider their common link to Fugger. The Fugger collections were not by any means limited to books. We have already noted Raimund's interest in antiquities, which Hans Jacob continued.[34] Raimund also had a considerable interest in musical instruments, with a passion above all for the lute, and amassed a collection of instruments so vast it is difficult to imagine how it could be stored.[35] The Fuggers were active patrons of the arts who commissioned sculpture, architecture, and large numbers of paintings from artists such as Hans Maler and Titian.[36] Hans Jacob, working with Strada, acquired a very significant collection of antique coins, which put them in an excellent position to produce jointly a thirty-volume catalog of drawings of ancient coins, an enormous undertaking.[37] Another Fugger, Marx, had an avid interest in mathematics and collected mathematical instruments. We know much less about the family's interest in *naturalia*, this being virtually unexplored territory in Fugger studies. The Fuggers collected gemstones and jewelry, including four pieces originally from the Burgundian treasury, and not infrequently resold them to such clients as the Habsburg emperors, the Medicis, and the sultan of Turkey.[38] We know of individual purchases of coral objects and so forth, but much work remains to be done on the full extent of Fugger collecting.[39] Antiquities, coins, gems, and scientific instruments are among the objects that formed the core of any humanistically oriented collection, that is, the type of collection we find among the nobility of Europe north of the Alps.

While in Hans Jacob's service, Quiccheberg apparently devised a thematic ordering system for the Fugger library, perhaps in direct collaboration with Fugger himself, based upon the work of Conrad Gesner.[40] Once Quiccheberg and Fugger moved to the court in Munich, they put into place a similar cataloguing system for Albrecht's library. This system certainly formed the conceptual basis for the organizational scheme Quiccheberg developed for the Wittelsbach collections and presented in his *Inscriptiones vel tituli*.

The exact circumstances of Strada's and Quiccheberg's employment and activities under Hans Jacob Fugger remain to be researched, as does a detailed study of the collecting activities of Fugger under Albrecht V. But it should already be clear that Hans Jacob played a key role in the formation of the *Kunst-* or *Wunderkammer* in the Germanic territories. Albrecht V's collections, while predating the arrival of Fugger, underwent a massive increase in scale and a change in nature just as his association with them begins. And the Bavarian collections, while not the very earliest in the region, Ambras in particular predating them, are the first to lay claim through their variety and their mode of display to being a site for the study and accumulation of universal knowledge, and to the practical application of that knowledge in the governance of the state. The more famous collections

of Maximilian in Vienna and Rudolf II in Prague are conceptually related to those of Munich, which should hardly be surprising given the role of intermediary played by Jacopo Strada. It is tempting to think, and may well be the case, that two qualities of the Munich collection relate directly to the connection with Fugger: here I speak of the collection as systematically arranged, and of the clear imperative to put the collection to direct practical use. The Fugger's own collections shaded imperceptibly into the conduct of their business, with the library being the clearest indication: the Fuggers effectively compiled two different sorts of library. One was a magnificent example of a humanist and antiquarian collection, primarily of intellectual and aesthetic interest, with precious manuscripts, a remarkably complete set of standard and obscure works of the Greeks, the Romans, Patristic texts, and works of humanist scholarship. The other library was a more immediately pragmatic reference source for business, that would have contained atlases and travel literature, treatises on accounting, mining, law, and so forth. On a more conceptual level, we would do well to recognize that the vast amount of data necessary to the running of the Fugger firm, in the form of business records, newsletters, and other accounts of current events, inventories, and even the commercial goods themselves, presented a powerful challenge in terms of efficient storage and retrieval. Hans Jacob Fugger's interest in ordering systems had a practical origin as well as a humanist one.

COMMERCE IN THE CABINET OF CURIOSITIES

In closing, I would like to think a bit about commerce *in* the *Wunderkammer*. Certainly the financial basis of the collections of the nobility is clear. The earliest of these assemblages were neither collections of art nor of curiosities, although they may well have contained such objects, but rather were treasuries. Gold and silver work, gems and jewelry, even reliquaries were assets that could be and were sold off to raise ready cash. In the case of Munich, in 1565 (not coincidentally the year Quiccheberg's treatise was published, and the year Hans Jacob Fugger entered Albrecht's service) Albrecht V was the first Wittelsbach ruler to declare certain objects, including two narwhal tusks, the inalienable property of the dynasty, to be passed on to later generations with the stipulation that they never be sold.[41] By and large, collections of the *Wunderkammer* type continued to emphasize monetarily valuable objects, most of them acquired through mercantile houses like those of the Fuggers. These objects moved in and out of the collections in an economy of their own, both to generate cash and to cement relationships with other princes and scholars.

The *Wunderkammern* served also as repositories for intellectual capital, functioning in a not dissimilar way to universities and their collections

today. Antiquities and numismatic collections were fundamental resources for study of the histories, languages, and cultures of the ancient world.[42] Products of metalsmiths, turners, jewelers, and armorers served to stimulate technical developments both by injecting capital into the higher ends of production and by acquiring examples of nonlocal techniques. *Wunderkammern* and other such collections similarly encouraged the development of scientific instruments, and therefore of scientific endeavor. We can even think of the *Wunderkammern* as assemblages of examples of local and exotic raw materials and processes; there is for instance a consistent interest in mining to be found in these collections—think back to the origins of Fugger wealth, and noble wealth, in mines for precious ores.

Objects were not the only items collected in *Wunderkammern*. Scholars, craftsmen, and other specialists were just as eagerly acquired. Jacopo Strada, for instance, begins working with Fugger, is brought into Albrecht's service, and ends up with Maximilian. Quiccheberg, a physician by training, moves from a university setting at Ingoldstadt to work for Fugger and then Albrecht. Hans Jacob Fugger himself was acquired by Albrecht V in what was essentially a financial transaction between Albrecht and the house of Fugger. These were the elite of the collections personnel, but there were also printers and bookbinders, turners and jewelers, armorers, equerries, and others attached to the service side of the collections.

This brings us to another very interesting point that emerges from looking closely at the infrastructure of Albrecht's collections, using Quiccheberg's text as a lens to help us focus. Almost all attention to these collections has gone into reconstructing first their contents and then their arrangement. Scholars have looked at Quiccheberg, deservedly so, primarily for the intriguing evidence he presents about what was collected and about how it was ordered. But the system of classes and inscriptions for objects is only a part of his treatise. He argues also for conceiving of the collections as one part of a larger complex of workshops and ateliers, including a printing room, a mint, and a pharmacy.[43] In turn, this brings us to a question of access: we expect the collections to be open to the duke and his family, to distinguished guests of the house and to resident and visiting scholars of high repute. But it is also clear that craftsmen and artisans could make use of it as well, for the good of regional technology and the economy.

Let me end with a quote from Quiccheberg:

> For I sense that it cannot be expressed by any person's eloquence how much wisdom and how much use for administering the state—in the civil and military spheres and the ecclesiastical and literary—can be gained from examination and study of the images and objects that I have described.[44]

This passage is found in the section of Quiccheberg's treatise in which he amplifies on the purposes and structure of the collection. In this passage and the one immediately preceding, he compares and contrasts the accumulation of objects with the training suggested by Cicero (the epitome of eloquence for the Renaissance) for the ideal orator. That person should be able to enumerate and learn about all things because all in the world that pertains to mankind is the natural domain of the orator. The collecting of objects, as enumerated by Quiccheberg, is an equivalent to the Ciceronian collecting of knowledge and ideas. But the equivalence is not exact, because however eloquent an orator may be, be it Cicero himself, the pragmatic value of the collection could not be conveyed as well by him as it could by the objects themselves.

And it is with the question of the practical use of the princely *Wunderkammern* that we reach the heart of the matter: these collections aided in the "administering of the state," the business of governance, and did it in very pragmatic ways. Certainly they were means of projecting images of princely wealth, power, erudition, and identity, but they were also very practical repositories of practical knowledge. As I have argued here, we must see this insistence on practicality as having origins in the dual concerns of merchants such as the Fuggers. It was they who dealt with and dealt in all the material things of the world, they who acquired these objects for themselves and for their clients, they who had the necessity and experience of ordering the world for both business and scholarly ends, they who best understood how these were the warp and woof of collecting, and how the two combined to create a representation, a self-portrait, of the collector. Certainly commerce and the merchants who practiced it largely determined which objects ended up in the *Wunderkammer*, and helped create and convey their life histories as well, points that deserve more scholarly attention. But we must also recognize that they played a strong hand in founding and shaping the *Wunderkammer* itself, bringing the threads of their long-established habits of organizing repositories into the tapestry. In this regard I think it is telling that Quiccheberg and Strada both got their start working with Hans Jacob in the Fugger collections, where business came first, and that Albrecht V's collections only started to take their full form as a *Wunderkammer* with the arrival of Fugger. Hans Jacob Fugger, rather like the Zelig of sixteenth-century collecting, turns up surprisingly often in the picture of the founding moments of the *Wunderkammer*.

Many of the conceptual underpinnings of this paper derive from discussion and debate with the members of the Microcosms Residential Research Group, which convened at the University of California Humanities Research Institute from January to June 1999: Ken Arnold, Rosemary Joyce, Rebecca Lemov, Sonnet Retman, and Bruce Robertson. I owe all of these colleagues and friends a great debt. As a visitor to the UCHRI Residency, Dirk Jansen was instrumental in bringing the significance of Hans Jacob Fugger for the *Wunderkammer* to my attention, and has since been an invaluable resource. The writing of this chapter was aided enormously by my indefatigable research assistants, Emily Peters and Amy Buono. This research was made possible by a Getty Grant Program Senior Collaborative Research Grant and funding from the University of California Office of the President, the Interdisciplinary Humanities Center of the University of California Santa Barbara, and the UCSB Committee on Research.

1. I introduce these terms from the beginning as a gesture toward the pioneering research on these early collections written by Julius von Schlosser. It is important to note that collections of the period were quite diverse in form and function, and we should be cautious about speaking about them as a unified phenomenon. For the sake of convenience, I shall use the term *Wunderkammer* for the remainder of this essay, recognizing that its use was infrequent in the period under consideration. For the purposes of this paper, I use the term to refer to heterogeneous collections that aspired to produce, store, and represent universal knowledge. Julius von Schlosser, *Die Kunst- und Wunderkammern der Spätrenaissance*, Vol. 11 of Monographien des Kunstgewerbes (Leipzig: Klinkhardt & Biermann, 1908).

The literature on curiosity cabinets, *Kunstkammern*, *Wunderkammern*, and the many other equivalent forms of early modern collecting is too vast to be given here. An excellent introduction to the topic and overview of many of the most important collections can be found in Oliver Impey and Arthur MacGregor, eds., *The Origins of Museums: The Cabinet of Curiosities in Sixteenth- and Seventeenth-Century Europe* (Oxford: Clarendon Press, 1985). For Albrecht V's collections, see especially Lorenz Seelig, "The Munich *Kunstkammer,*" 1565–1807, in the volume just mentioned; Jacob Stockbauer, *Die Kunstbestrebungen am Bayerischen Hofe unter Herzog Albrecht V. und seinem Nachfolger Wilhelm V.*, vol. 8 of *Quellenschriften für Kunstgeschichte und Kunsttechnik des Mittelalters und der Renaissance* (Vienna: Wilhem Braumüler Universitäts-Verlagbuchhandlung, 1874); and Herbert Brunner, *Die Kunstschätze der Münchner Residenz* (Munich: Süddeutscher Verlag, 1977). For Rudolf II's collections, see Robert John Weston Evans, *Rudolf II and His World: A Study in Intellectual History: 1576-1612* (Oxford: Oxford University Press, 1973); E. Fucikova, *Die Kunst am Hofe Rudolfs II* (Prague: Artia Verlag, 1988); and Thomas DaCosta Kaufmann, *The School of Prague: Painting at the Court of Rudolf II* (Chicago: University of Chicago Press, 1988).

2. See Seelig, "The Munich *Kunstkammer*," 83.

3. Michael Gorgas, "Animal Trade between India and Western Eurasia in the Sixteenth Century—The Role of the Fuggers in Animal Trading," in *Indo-Portuguese Trade and the Fuggers of the Sixteenth Century*, ed. Kuzhippalli Skaria Mathew (New Delhi: Manohar, 1977), 195–225, esp. 218–222.

4. Stockbauer, *Die Kunstbestrebungen am Bayerischen Hofe*, 91–107 passim.

5. Gorgas, "Animal Trade," 218–222.

6. See Hans-Olaf Boström, "Philipp Hainhofer and Gustavus Adolphus's *Kunstschrank* in Uppsala," in *Origins of Museums,* 90–101, here 91. Hainhofer's cabinet, here more literally a piece of furniture, was later purchased and presented to King Gustavus Adolphus, thus illustrating the migration of objects from source to merchant-trader to merchant-collector to royal collection.

7. Lorraine Daston, "The Factual Sensibilitys" *Isis* 79 (1988), 455.

8. Ken Arnold, *Cabinets for the Curious: Practicing Science in Early Modern English Museums*, Ph.D. diss., Princeton University, 1991 (UMI Dissertation Services, 1992), 139.

9. Ibid.

10. An admirable exception is Lisa Jardine's recent *Worldly Goods: A New History of the Renaissance* (London and New York: W. W. Norton, 1996). Her insights into the relation of commerce and intellectual life have helped shape the more specialized argument here presented.

11. Italo Calvino, *Invisible Cities*, trans. William Weaver (New York: Harcourt Brace Javonovich, 1974), 76.

12. The Microcosms Project is described in Mark Meadow and Bruce Robertson, "Microcosms: Objects of Knowledge," *AI & Society* 14 (2000), 223–229.

13. For Fugger trade with the New World, see Karl Heinz Panhorst, *Deutschland und Amerika; ein Rückblick auf das Zeitalter der Entdeckungen und die ersten deutsch-amerikanischen Verbindungen unter; besonderer Beachtung der Unternehmungen der Fugger und Welser* (Munich: E. Reinhard, 1928), Konrad Häbler, *Die Geschichte der Fugger'schen Handlung in Spanien*, Vol. 1 of Socialgeschichtliche Forschungen, Ergänzungshefte zur Zeitschrift für Social- und Wirthschaftsgeschichte (Weimer: E. Felber, 1897); Hermann Kellenbenz, *Die Fugger in Spanien und Portugal bis 1560: Ein Großunternehmen des 16. Jahrhunderts* (Schriften der Philosophischen Fakultäten der Universität Augsburg, 33:1), 3 vols. (Munich: Verlag Ernst Vögel, 1990).

14. Panhorst, *Deutschland und Amerika*, passim, esp. 278–283. A shift in Iberian politics effectively ended this venture before it began.

15. The Fugger newsletters have never been published in their entirety. Nonetheless, several extensive sets of selected examples give a good sense of their contents and breadth of coverage. See, for example, Victor Klarwill, *Fugger-Zeitungen: Ungedruckte Briefe an das Haus Fugger aus den Jahren 1568–1605* (Vienna: Rikola Verlag, 1923); Victor von Klarwill, ed., *The Fugger News-Letters: Being a Selection of unpublished letters from the Correspondents of the House of Fugger during the years 1568–1605* (London: John Lane The Bodley Head, 1924); V. von Klarwill, ed., *The Fugger News-Letters, Second Series: Being a further Selection from the Fugger papers specially referring to Queen Elizabeth and matters relating to England during the years 1568–1605* (London: John Lane The Bodley Head, 1924); and George T. Matthews, ed., *News and Rumor in Renaissance Europe (The Fugger Newsletters)* (New York: G. Putnam's Sons, 1959).

16. For the Fugger libraries, the standard references remain Otto Hartig, *Die Gründung der Münchner Hofbibliothek durch Albrecht V. und Johann Jacob Fugger*; (Munich: Verlag der Königlich Bayerischen Akademie der Wissenschaften, 1917); and Paul Lehmann, *Eine Geschichte der alten Fuggerbibliotheken*, 2 vols., Studien zur Fuggergeschichte, 12 (Tübingen: J. C. B. Mohr, 1956–1960).

17. For Hans Jacob Fugger, see Wilhelm Maasen, *Hans Jakob Fugger (1516-1575): Ein Beitrag zur Geschichte des XVI. Jahrhunderts*, Vol. 5 of Historische Forschungen und Quellen (Munich: Datterer, 1922); Lehmann, *Eine Geschichte der alten Fuggerbibliotheken*, Vol. 1, esp. 41–73; and Hartig, *Die Gründung der Münchner Hofbibliothek*, 193–223. For Anton Fugger, see Herman Kellenbenz, *Anton Fugger (1493-1560)*, Weissenhorn (1993) and Johannes Burkhardt, ed., *Anton Fugger (1493-1560): Vorträge und Dokumentation zum fünfhundertjährigen Jubiläum*, Vol. 36 of (Studien zur Fuggergeschichte) (Weissenhorn, A. H. Konrad, 1994).

18. For Hans Jacob Fugger's education, see Lehmann, *Eine Geschichte der alten Fuggerbibliotheken*, Vol. 1, 42–44; Hartig, *Die Gründung der Münchner Hofbibliothek*, 194–196; and Maasen, *Hans Jakob Fugger*, 3–12.

19. See Maasen, *Hans Jakob Fugger*, 6. For Johannes Secundus, see Dougall Crane, *Johannes Secundus, His Life, Work, and Influence on English Literature* (Beiträge zur englischen

Philologie, 16) (Leipzig: B. Tauchnitz, 1931), and Clifford Endres, *Johannes Secundus: The Latin Love Elegy in the Renaissance*, (Hamden, Conn.: Archon Books, 1981).

20. For Viglius, see E. H. Waterbolk and Th. S. H. Bos, eds., *Vigliana : bronnen, brieven en rekeningen betreffende Viglius van Aytta* (Estrikken, 50) (Groningen: Frysk Ynstitut en Historisch Instituut R. U. Grins, 1975); and Folkert Postma, *Viglius van Aytta als humanist en diplomaat (1507-1549)*, (Zutphen: Walburg Pers., ca. 1983).

21. This anecdote is recounted by Hans Jacob in Cod. Vat. Lat. 6412, fol. 105. For Alciati, see Ernst von Moeller, *Andreas Alciati (1492–1550): Ein Beitrag zur Entstehungsgeschichte der modernen Jurisprudenz* (Studien zur Erläuterung des Bürgerlichen Rechts, 25) (Breslau: M. & H. Marcus, 1907); Frederik Willem Gerard Leeman, *Alciatus' Emblemata: denkbeelden en voorbeelden* (Groningen: Bouma's Boekhuis, 1984); and Johannes Köhler. *Der "Emblematum liber" von Andreas Alciatus (1492–1550): Eine Untersuchung zur Entstehung, Formung antiker Quellen und pädagogischen Wirkung im 16. Jahrhundert*, (Beiträge zur historischen Bildungsforschung, 3) (Hildesheim: A. Lax, 1986).

22. For Hieronymus Wolf, see Hieronymus Wolf, *Der Vater der deutschen Byzantinistik: das Leben des Hieronymus Wolf von ihm selbst erzählt*, trans. Hans-Georg Beck (Miscellanea Byzantina Monacensia, 29) (Munich: Institut für Byzantinistik und neugriechische Philologie der Universität, 1984). For Ascham, see Alfred Katterfeld, *Roger Ascham: Sein Leben und seine Werke* (Strasbourg: K. J. Trübner, 1879), esp. 140–41, and Lawrence Ryan, *Roger Ascham*. (Stanford, Calif.: Stanford University Press, 1963). In 1551, Ascham was a houseguest of Hans Jacob Fugger.

23. For Farnese, see Léon van der Essen, *Alexandre Farnèse, prince de Parme, gouverneur général des Pays-Bas (1545–1592)*, (Bibliothèque du seizième siècle) (Brussels: Librairie nationale d'art et d'historie, 1933); Antonio Bezzi, *Alessandro Farnese: una vita per un ideale* (Collana di storia, arti figurative e architettura, 12) (Parma: L. Battei, 1977); and Alessandro Pietromarchi, *Alessandro Farnese: l'eroe italiano delle Fiandre* (Le Storie della Storia, 13) (Rome: Gangemi, 1998). For Madruzzo, see Antonio Monti, *Filippo II e il card. Cristoforo Madruzzo, gobernatore di Milano (1556–1557)* (Milan: Società editrice Dante Alighieri di Albrighi, Segati & Co., 1924). For Hosius, see Joseph Lortz, *Kardinal Stanislaus Hosius: Beiträge zur Erkenntnis der Persönlichkeit und des Werkes* (Braunsberg: Herder, 1931). For Truchsess, see Bernhard Schwarz, *Kardinal Otto Truchsess von Waldburg, Fürstbischof von Augsburg: sein Leben und Wirken bis zur Wahl als Fürstbischof von Augsburg (1514–1543)* (Geschichtliche Darstellungen und Quellen, 5) (Hildscheim: F. Borgmeyer, 1923).

24. Hans Jacob Fugger, *Geheimen Ehrenbuch Mannsstammens und Namens der Eerlichen und altloblichen Fuggerischen Geschlechts*, 1541–1545. Copies of this manuscript may be found in the Nuremberg Germanisches Museum and in the Fugger Museum in Augsburg. Hans Jacob Fugger, *Warhafftige Beschreibung Zwaier Inn ainem Der aller Edlesten vralten vnd hochloblichisten Geschlechten der Christenhait des Habspurgischen vnnd Osterreichischen geblüets, sampt derselbigen lobwurdigen herkommen, Geburten, leben, Regiment vnnd Ritterlichen gethaten, Von dem anfanng biss auff die Vnuberwindtlichisten Grossmechtigisten Fursten vnd herren, herrn Carolum, den funfften vnd Ferdinandum, der ersten, Römischen Kaiser vnd Könige, auch recht ordenliche Erwölte vnd gekrönte, Obriste haupter der Christenhait*, 1555. Maasen doubts that Fugger was in fact the author of this compendious work, suggesting instead that he may have served merely as editor and that the writing itself was by the Augsburg cobbler and historian Clemens Jäger. See Maasen, *Hans Jakob Fugger*, 59–73, esp. 67–68. Copies of this work reside in the Staatsbibliotheken in Munich and Vienna. Bibliographic refs. to Fugger and Habsburg histories.

25. Quiccheberg, *Inscriptiones vel tituli Theatri amplissimi complectentis rerum vniuersitatis singulas materias et imagines eximias, ut idem recte quoque dici possit: Promptuarium artificiosarum miraculosarumque rerum, ac omnis rari thesauri et pretiosæ supellectilis, structuræ atque*

picturæ, quæ hic simul in theatro conuqiri consuluntur, ut eorum frequenti inspectione tractationecque, singularis aliqua rerum cognitio et prudentia admiranda, citò, faciliè ac tutò comparari possit. (Munich: Adam Berg, 1565).

26. See Maasen, *Hans Jakob Fugger*, 74–90, on Hans Jacob Fugger's role as a patron of scholarship and the books dedicated to him as a result.

27. For Hans Jacob Fugger at the court of Ferdinand, see Maasen, *Hans Jakob Fugger*, 8–10.

28. For Hans Jacob Fugger's role in Augsburg politics, see Maasen, *Hans Jakob Fugger*, 12–30.

29. For Hans Jacob Fugger at the court in Munich, see Maasen, *Hans Jakob Fugger*, 45–58.

30. For the Byzantine holdings, see B. Mondrain, "Copistes et collectionneurs de manuscrts grecs au milieu du XVIe Siècle," *Byzantinische Zeitschrift* 84 (1991/92): 354–390.

31. Wolf began his employment as librarian to the Fuggers in 1551. The great librarian Conrad Gessner had been offered the position in 1545, but the arrangements never came to fruition. Wolf remained in this post until 1557. See Lehmann, *Eine Geschichte der alten Fuggerbibiliotheken*, Vol. 1: 50–57.

32. Jacopo Strada began working for Hans Jacob Fugger while living in Nuremberg in 1544. At Hans Jacob's request, and with his financial support, Strada prepared a thirty-folio volume set of numismatic drawings to serve as a standard reference for Fugger's collections. He continued to serve Fugger as an intermediary in the purchase of antiquities and coins in Rome. Strada produced architectural drawings for Albrecht V's Antiquarium in Munich, as well as designing his own house in Vienna. He entered the service of the Habsburgs in 1558, and continued in their employ until 1579. For Strada's work in the German-speaking world, see Renate von Busch, *Studien zu deutschen Antikensammlungen des 16. Jahrhunderts* (Diss. Tübingen: 1973). For other aspects of Strada's career, see Dirk Jansen, "Jacopo Strada (1515–1588): Antiquario della Sacra Cesarea Maestà," *Leids Kunsthistorisch Jaarboek*, I (Leiden: 1982), 57–69; E. Fucíková, "Einige Erwägungen zum Werk des Jacopo und Ottavio Strada," *Leids Kunsthistorisch Jaarboek*, I (Leiden: 1982), 339–353; Dirk Jansen, "Jacopo Strada et le commerce d'art," *Revue de l'art* 77 (1987), 11–21; idem, "Gli strumenti del mecenatismo: Jacopo Strada alla corte de Massimiliano II," in *"Familia" del Principe e famiglia aristocratica* (Biblioteca del Cinquecento, 41) ed. Cesare Mozzarelli (Rome: Bulzoni, ca. 1988), 681–715; idem, "Example and examples: The potential influence of Jacopo Strada on the development of Rudolphine art," in *Prag um 1600: Beiträge zur Kunst und Kultur am Hofe Rudolfs II*, (Freren/Emsland: Luca, 1988), pp. 132–146; idem, "Der Mantuaner Antiquarius Jacopo Strada," in *Fürstenhöfe der Renaissance: Giulio Romano und die klassische Tradition* (Vienna: Kunsthistorisches Museum, 1989), 308–323; idem, "Jacopo Strada's Antiquarian Interests: A Survey of his Musaeum and its Purpose," *Xenia: Semestrale di Antichità*, 21 (1991), 59–76; and idem, "The Instruments of Patronage: Jacopo Strada at the Court of Maximilian II: A Case Study," in *Kaiser Maximilian II: Kultur und Politik im 16. Jahrhundert* (Wiener Beträge zur Geschichte Neuzeit, 19), ed. Friedrich Edelmayer and Alfred Kohler (Vienna: Verlag für Geschichte und Politik; Munich: Oldenbourg, 1992), 182–202.

33. Quiccheberg came into the employ of the Fuggers in 1555, first as physician to Anton Fugger "dero leib zu warten und zu artzneyen," but was working as librarian at least as early as 1559. For Quiccheberg, see esp. Harriet Roth, *Der Anfang der Museumslehre in Deutschland: das Traktat "Inscriptiones vel tituli theatri amplissimi" von Samuel Quiccheberg; lateinisch-deutsch*, Berlin, 2000; and Patrice Falguières, "Fondation du Théâtre ou Méthode de l'exposition universelle: les *Inscriptions* de Samuel Quicchelberg (1565)," *Les Cahiers du Musée National d'Art Moderne* 40 (1992), 91–109. For Quiccheberg at Munich, see Otto Hartig, "Der Arzt Samuel Quicchelberg, der erste Museologe Deutschlands, am Hofe Albrechts V. in München," *Bayerland* 44 (1933), 630–633.

34. For Raimund Fugger's collections of antiquities, see Norbert Lieb, *Die Fugger und die Kunst*, Vol. 2 of Studien der Fuggergeschichte (Munich: Verlag Schnell und Steiner, 1952–58), 46–51, 349–351.

35. Raimund Fugger's astonishing collection of lutes and harpsichords was cataloged in 1566, at the time they were acquired en masse by Albrecht V. See Stockbauer, *Die Kunstbestrebungen am Bayerischen Hofe*, 81–84.

36. The best work on the art patronage of the Fuggers remains Norbert Lieb, *Die Fugger und die Kunst*, see esp. Vol. 2, 303–305 for Titian.

37. Jacopo Strada, *Antiquorum numismatum*. Later an excerpted version was published as *Epitome Thesavri antiqvitatvm, hoc est, impp. Rom. Orientalivm et Occidentalivm Iconvm ex antiquis Numimatibus quam fidelissimie deliniatarum* (Lyon: 1553). For Albrecht V's numismatical collections, see Stockbauer, *Die Kunstbestrebungen am Bayerischen Hofe*, 70–72.

38. For the Fugger collections and trade in jewels, see Lieb, *Die Fugger und die Kunst*, Vol. 2, 133–138, and esp. 137–138 concerning the Burgundian gems and their eventual resale.

39. For the purchase of coral, see Lieb, *Die Fugger und die Kunst*, Vol. 2, 140.

40. See Lehmann, *Eine Geschichte der alten Fuggerbibiliotheken*, Vol. 1, 57.

41. See Seelig, "The Munich *Kunstkammer*," 76. Albrecht V was preceded in this by the Habsburgs Maximilian II and Ferdinand II, who declared certain artifacts inalienable property only a year earlier in 1564. These included an agate bowl and a "unicorn" horn, another narwhal tusk. See Elisabeth Scheicher, "The Collection of Archduke Ferdinand II at Schloss Ambras," in *The Origins of Museums*, 29–38, here 30; and Rudolf Distelberger, "The Habsburg Collections in Vienna during the Seventeenth Century," in *The Origins of Museums*, 39–46, here 43.

42. For the intellectual importance of antique collections, see esp. Horst Bredekamp, "Antikensehnsucht und Maschinenglauben," in *Forschungen zur Villa Albani: Antike Kunst und die Epoche der Aufklärung* (Frankfurter Forschungen zur Kunst, 10), ed. Herbert Beck and Peter Bol (Berlin: Gebr. Mann, 1982). For the conceptual importance of ancient coins to the intellectual premises of the curiosity cabinet, see Arnold, *Cabinets for the Curious*, 42–87.

43. Quiccheberg, *Inscriptiones vel tituli*, Civ r–Di r.

44. Ibid., Di v–Dii r.

Practical Alchemy and Commercial Exchange in the Holy Roman Empire

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By the mid-sixteenth century, alchemy was of widespread interest in the Holy Roman Empire. No longer the preserve of learned natural philosophers and initiates alone, the alchemical arts engaged princes, pastors, and craftspeople, both male and female. This diverse group of enthusiasts devoured alchemical literature as publishers ushered ancient and modern authors into print; they also traded techniques with fellow students of nature and bought recipes from peddlers of alchemical secrets. Not surprisingly, given alchemy's wide purview of the theoretical and the practical as well as the mystical and the material, alchemical practitioners differed about how precisely to define their art, how to master it, and what to do with it. By the end of the century, practitioners increasingly disagreed: what exactly was alchemy, and, as it gained publicity and the support of political leaders, what were its goals to be?

In this paper, I argue that in the late sixteenth century, alchemists offered at least two different answers to these questions. The first view, rather traditional, saw alchemy as a natural philosophy which sought to understand God through his greatest revelation: nature. From this perspective, even the practice of alchemy was pious. In using his art to heal natural bodies (whether human or metallic), the philosophical alchemist sought nothing less than the regeneration of the world by cleansing it of impurities resulting from the Fall of Adam and Eve. A second strain in early modern alchemy took a much more pragmatic perspective, emphasizing instead alchemy's utility and productivity in the world of things. This practical alchemy was markedly commercial in the sense that it was both accessible through and supported by a growing market in alchemical goods and services. Though these two threads in early modern alchemy were not identified exclusively with particular individuals or groups (indeed, a single individual could exhibit both tendencies), nonetheless, they were increasingly in conflict

in this period. Both had potential to triumph and determine whether alchemy was ultimately to be about understanding God and learning or profit and the production of things.

Over the past few decades, historians have done much excellent work on the philosophical and spiritual aspects of alchemy. They have shown that early modern European scholars and political elites viewed alchemy not only as *possible*, but often as *central* to their intellectual, religious, and political activities.[1] In focusing on alchemy as an idea, philosophy, or metaphor, and explaining why it made sense to early modern Europeans, these historians have been pivotal in reevaluating alchemy's marginality and demonstrating its importance and legitimacy both before and during the formulation of the new science. It has been much more difficult, however, to appreciate alchemical practitioners who claimed to be able to *do* alchemy successfully, to actually transmute metals or create the philosophers' stone, largely because it seems so obvious to us in the twenty-first century that it is *not* possible to create gold out of iron.[2] And yet alchemy as a practice and the alchemical production of things was just as important to early modern patrons and practitioners as it was as an idea. As alchemists' contracts, proposals, and laboratory reports reveal, a vital community of practitioners was at work in the Holy Roman Empire on a range of alchemical projects. If we wish to understand the relationship between alchemy and commerce, we must first understand the *practice* of alchemy and its relationship to emerging markets and the world of goods.

ALCHEMY AS COMMODITY

Interested patrons and practitioners could find a great deal of alchemical knowledge for sale in the sixteenth century. Novices who wished to pursue their interest in alchemy would have found a variety of literature in the book stalls, where ancient and medieval Islamic and Christian authors joined more modern authorities such as Paracelsus (ca. 1493–1541).[3] Practical books in the vernacular sold particularly well and did much to expand the audience for alchemy. William Eamon has noted how printers often amended these "how-to books" to make them more accessible for audiences from the middling classes, inserting indexes, prefaces, and translations of difficult or technical terms.[4] The 1570 version of the *Kunstbüchlein* (or skills booklet) titled *Alchimia*, for example, began with an "Explanation of Some Latin Words" that translated *sol* to gold, *corpus* to "any metal or material," and so on.[5] With these sorts of additions, Eamon notes, "philosophical traditions such as alchemy were given a new relevance by being placed within the reach of general readers."[6] Furthermore, students of alchemy who did not

wish to (or could not) buy an entire book might come across a fellow enthusiast willing to share a recipe for a small fee or a skilled practitioner willing to instruct them in a particular process in exchange for pay. Alchemy had become much more accessible and widely dispersed than it had been to its medieval devotees.

The career of the Wolfenhüttel alchemist Philipp Sömmering (ca. 1535–75) provides a rare glimpse of a practical alchemist negotiating this market of alchemical expertise. The son of a pastor in Thombach, Sömmering attended school before taking up a series of positions in the Lutheran Church. When war and a dispute disrupted his position as a pastor in 1555, Sömmering set off to wander, by his own account, two hundred miles throughout the Holy Roman Empire. On his journeys, Sömmering met two men from whom he obtained his first alchemical book. Sömmering procured from a fellow pastor a second book, in which he reportedly read about certain distilling techniques. With only these two books, Sömmering later reported, he began to try his hand at alchemy. He furthered his studies by paying a woodcarver in Erfurt 5 thaler to teach him distillation and sublimation, then copied down the varieties of plants and bought 11 thaler worth of herbs from an apothecary.[7]

Still in Erfurt, Sömmering discussed the art of alchemy with someone he identified as a "Philosopher" and bought two more books: the *Book of Isaac* ("in which there are many good things") and the *Hexameron of Bernardus*.[8] Together these two books cost Sömmering the considerable sum of 400 thaler, an expense he shared with Ahel Scherdinger, confessor to the Count of Hennenberg. Scherdinger and Sömmering clearly viewed these books as an investment, for they made an agreement to pursue alchemy together and to split their profits equally. Sömmering had the further good fortune of learning "a highly secret art, namely the regulation of the fire" from an alchemist named Martin Gurlach. This cost Sömmering nothing more than perhaps the price of a few beers, inasmuch as he reportedly got the information from Gurlach "while drinking." Having purchased books, recipes, and skills from a variety of people, Sömmering was thus ready to work as an alchemist. In 1566 he and Scherdinger signed a contract to produce the philosophers' stone for Duke Johann Friedrich of Sachsen-Gotha.[9]

Several aspects of this story are remarkable. The impressive array of people from whom Sömmering bought his knowledge—including pastors, another alchemist, an apothecary, and a philosopher—is an indication of how widely dispersed alchemical knowledge had become. Similarly, that knowledge came in a wide variety of forms. Sömmering not only bought books, but gleaned alchemical secrets during official lessons (from the woodcarver) and casual conversation (from the alchemist). Most strikingly, however, Sömmering's tale illustrates the extent to which alchemy was for

sale by the mid-sixteenth century. Alchemical knowledge itself had become a commodity.

Alchemy's entrance into the marketplace created new forms of alchemical knowledge and new standards for measuring it. Finding it difficult to place lifetimes of learning and vast philosophical systems in compact (and marketable) books, sellers often repackaged this knowledge in the form of recipes and processes, eliminating (or at least deemphasizing) larger theoretical frameworks.[10] At the same time, the market forced buyers and sellers to place a monetary value on alchemical knowledge. As a result, the kind of alchemy which enthusiasts bought and sold at the end of the sixteenth century increasingly came to emphasize qualities that promised immediate returns and highlighted profit and utility.

Nowhere was this new emphasis on alchemy's productive potential clearer than in the manner its practitioners promoted themselves to likely patrons. One strategy alchemists used to peddle their wares was to highlight the potential profits their processes could offer. When the metallurgist, mint official, and technical author Lazar Ercker (ca. 1530–94) wrote to Duke Julius of Braunschweig-Wolfenbüttel (1528-89), he underscored the money, quite literally, that he could help generate.[11] In this 1585 letter, Ercker described a process by which "using a powder, I can bring Rheinisch, or other low quality gold, in a few days to proper Ducat-quality gold," which was worth twice as much. Ercker claimed that he could transmute 100 marks (about 233.85g) of Rheinisch Goldgulden a week, with an extra cost of 10 thaler "for the coals and all the Instruments." Promoting the efficiency of his process, Ercker noted that he could make use of the by-products as well. "The silver which the Rheinisch Goldgulden have in them will be melted out of the powder again," he boasted, "and the gold which the powder has also absorbed, of which there is little, will be separated out and used as is useful."[12]

Ercker emphasized the profits his process would generate. "I am of the humble opinion," he wrote, "that for every hundred Marks of Rheinisch Goldgulden, given the initial costs, there should be a surplus and financial profit of at least seventy or eighty Thaler."[13] As support for his claims, Ercker cited his own results using the technique to mint coins for a merchant from Nuremberg. The merchant profited handsomely (according to Ercker) producing as much as 2,000 thaler in a year. In Duke Julius's case, Ercker pledged, the profits promised to be even greater. "In my opinion," he wrote to Julius, "it would be much more lucrative and useful to Your Princely Grace because Your Princely Grace can invest [*verlegen*] much more than a merchant—which, however, can not happen at all without this invented art of mine."[14]

As Ercker's pledge suggests, practical alchemists often marketed their skills not only by underscoring productivity, but also efficiency. Their claims

were usually very specific, outlining the exact ingredients, in precise quantities, and the resulting amount of precious metal. Petr Hlavsa of Liboslav, the manager of Bohemian magnate Vilém-Rožmberk's (1535–92) Prague alchemical laboratories, described one alchemist's technique in just such detail in 1574.[15] For this process, which according to Hlavsa was "truly in accordance with the alchemical art," the alchemist Cristoff von Hirschenberg started with 8 Loth gold and 8 Loth silver.[16] Using "the accompanying powders and materials," Hirschenberg increased the proportion of gold, producing 5 Loth silver and 11 Loth gold "which should pass any tests and should remain fixed."[17] The alchemist Michael Polhaimer (1566/67–98) signed a contract in 1595 with Count Wolfgang II von Hohenlohe (1546–1610) to perform a slightly different process: an "augmentation" that would transmute 2 pounds (or 64 Loth) of mercury into 10 Loth of "fine silver."[18] Such processes were typical among practical alchemists in their specificity and accuracy; they also reflect an awareness of the patrons' desire to know exactly how much money they would have to invest in this type of work and what kind of rewards it could yield.

When practical alchemists did win the support of patrons, they typically set down the terms of employ in a very businesslike contract. These contracts transferred the specific details of the proposals into a legally binding document, stipulating in detail the type of processes the alchemist was to carry out and the deadline for completion, as well as the patron's duties in terms of payment, facilities, and materials. The contract that Philipp Sömmering and Abel Scherdinger entered into in 1566 shortly after they acquired their two prized books was typical. After demonstrating their art at the court of Duke Johann Friedrich of Sachsen-Gotha, the alchemists agreed to give the duke 10 percent of the proceeds from their philosophers' stone in exchange for an advance of 760 thaler, raw materials, and equipment.[19] This kind of arrangement differed from a more general patronage relationship in its specificity. Whereas many philosophical alchemists counted princes as their patrons, they never signed contracts of this type. Instead, they were typically hired as court physicians, expected to perform a variety of duties associated with their position. The contracts that practical alchemists signed, on the other hand, were ordinarily limited to the performance of a single, specific process.[20]

USEFUL ALCHEMY AND THE WORLD OF THINGS

The range of skills that practical alchemists claimed to possess, however, could encompass anything from medicine to metallurgy. The entire laundry list appeared in a 1597 text written by Alexander Lauterwald in praise of the

alchemical arts.[21] Lauterwald's interlocutor in the treatise and the embodiment of alchemy, Chimia, proclaims proudly that "no one can do without me" before outlining the full range of activities—from cooking to the fabrication of precious stones—in which she can be of use. Chimia reserves her strongest claims of utility, however, for mining and medicine.

> To that I must add even more / The minerals must choose me as well / when they want to separate themselves from others, / from the ore, in which they languish, / despairing that they are not bright. All of this I do without danger. / Indeed, I make all the metals right. / [Without me] they can not come clean, / nor can they please people; / Since they aren't properly worked, / They crumble under use. / Nor can the ore be used / If it isn't first cleansed through my breath, / [made] pure and clean / Such things know my children alone. / They are the goldsmiths and assayers, / The mint masters and jewelers / I can bring forth gemstones as well / Make glass that can bend light / Many lovely distillations / Are used for medicine / In which the great secret is buried / He who achieves this, need not worry.[22]

Although today we tend to think of medicine, metallurgy, and the production of jewels as separate activities, Lauterwald's poem reminds us that in the minds of early modern Europeans, they were closely related activities, all of which could fall within the provenance of the alchemist.

Practical alchemy was, therefore, by no means limited to the production of noble metals. Alchemists frequently carried out their metallurgical projects alongside medicinal ones, such as the "theophrastian universal medicine" that alchemist Michael Heinrich Wagenmann vom Hoff contracted with Duke Friedrich of Württemberg (1557–1608) to make in December 1598.[23] Some of these medicines were more obviously connected to precious metals, such as the *olium solis et lunae* (oil of sun [gold] and moon [silver]) which Melchior Hornug prepared with "a little of our gold" from his patron's mine in Reichenstein, Silesia, or the seemingly omnipresent medicinal golden liquid, potable gold.[24] The close connection that Paracelsus and others drew between the new chemical medicine and alchemy, in addition to the overlap in distilling skills involved in both, ensured that most practical alchemists might turn their attentions to medicine as easily as to metals. The proper powder or liquor might just as easily "heal" or purify a human body as a metallic body.

Practical alchemy could be useful in other ways as well. A female alchemist named Anna Zieglerin (ca. 1556–75) extended the alchemical concern with generation beyond metals to animal and vegetable material. In an unpublished booklet written in 1573 for her patron, she described a method "for when one wants to have cherries, grapes or other good, ripe fruit early

in winter."[25] Most remarkably, Zieglerin shared with Duke Julius of Braunschweig-Wolfenbüttel her unique understanding of the homunculus, imparting a method by which the tincture used for transmuting metals might also be used to engender children. Zieglerin recommended that women having difficulty getting pregnant drink the alchemical tincture daily. When the pregnancy succeeded and the baby was born, the mother should "let the baby taste no mother's milk and give it nothing to eat or drink . . . [but] three times a day let it have three drops [of the tincture] in its mouth."[26] Here Zieglerin demonstrated yet again just how interconnected minerals, plants, and animals could be in view of the alchemist. Just as metals like gold could be used to cure humans, so too could babies thrive on the same tincture that brought noble metals out of base.

Despite all of these other activities, the transmutation or multiplication of metals remained the heart of the practical alchemical enterprise and the skill for which patrons seemed most to value its practitioners. Proposals and claims varied widely, but practical alchemists ordinarily had either a tincture or a "process" for this purpose. Although tinctures also had medicinal uses, in the context of metallic transmutation or multiplication the term designated a liquid or powder that could "tinge" or transmute metals.[27] Typically alchemists already possessed the tincture and asked only for the chance to demonstrate its potential. The Cypriot alchemist Marco Bragadino (ca. 1545–91), for example, arrived in the Veneto in 1589 with his "medicine" and successfully demonstrated it by transmuting 1 pound of quicksilver under the critical eyes of two officials from the Venetian Mint and an assemblage of local nobility.[28] Occasionally practitioners claimed only to have a sure-fire recipe for the tincture rather than the substance itself, but they swore that they could produce it given the necessary materials and equipment.[29] A "process" or *Kunstwerk* (work of artistry or skill) most often described a recipe or method for multiplying metals, and characteristically required an initial investment from a patron to perform.

When practical alchemists successfully secured positions at the princely courts of the Holy Roman Empire, they frequently found themselves working alongside others in large alchemical laboratories. Such laboratories sprouted up in Saxony, Bavaria, Bohemia, Braunschweig-Wolfenbüttel, and Württemberg in the late sixteenth century, mini-alchemical workshops dotting the map of the Holy Roman Empire. The activities in these laboratories illuminate the extent to which practical alchemy was productive work. Although the types and extent of alchemical activity in each of these laboratories certainly varied, we can get a sense of the kind of work it was from a 1608 inventory of the laboratories that Duke Friedrich I set up in his southern German territory of Württemberg. This inventory, taken upon the Duke's death, provides a snapshot of the kind of alchemical activity that

went on at noble courts in the Holy Roman Empire. Friedrich's court physicians Abraham Schopf and Ulrich Porta, together with the manager of the alchemical laboratories Chrystoff Wagner, drew up a list of "all the transmutational and medicinal processes (*Stück*), in addition to raw and prepared materials, instruments, ovens, glasses, crucibles, cappels, and other tools required for work" found in the ducal laboratories. According to the list, Wagner himself was in the middle of eight different projects when the inventory was made.[30] In addition, the inventory listed five others at work in the laboratories. Andreas "the chamberboy," for example, had already finished two vials of a tincture, soon to be demonstrated in a projection, and was in the midst of a process which was to produce gold from mercury combined with a certain elemental substance. Daniel Keller, another assistant, was working on both a tingeing process and the multiplication of a tincture, while Johan Geißler was also finishing a tincture which he was shortly to demonstrate. Georgius Butina was earning four gulden weekly working on an unnamed process for the duke and simultaneously working on a process of his own involving gold. The last assistant, Adam Wiera, had just finished a process that produced an entire pound of gold and would double in another six weeks (thus producing 2 pounds). There were apparently others at work in the laboratory as well, as the inventory noted that "what the other workers are carrying out . . . can also be inquired about."[31]

Taken together, these laboratories worked as a sort of alchemical manufactory-cum-workshop. Under the direction of Duke Friedrich's manager Chrystoff Wagner, each of these assistants annually earned from 52 to 208 gulden (plus, in several cases, two new outfits yearly) to work on various processes.[32] Interestingly, few of the assistants were working on processes that they had proposed to the duke; rather, Friedrich handed out processes he collected elsewhere, assigning them to individual assistants. We learn from the inventory, for example, that Daniel Keller's task was "a work of great importance at the command of His Princely Grace." Similarly, Andreas labored at "a work, which was mentioned to His Princely Grace by Gerbelium of Strasbourg." The exception was Georgius Butina, who was lucky enough to have "arranged with His Princely Grace license [to work on] his own invention of a process." Butina, however, was unusual. For the most part these assistants were hired hands, paid a yearly salary for producing alchemical goods on their sovereign's behalf.[33]

The activities in Duke Friedrich's laboratory demonstrate the extent to which early modern alchemy was involved in the production of *things*. This was productive knowledge, and its practitioners put it to work in creating a variety of useful items. Indeed, this kind of alchemy seems strikingly mundane. Because we imagine alchemical laboratories to be dark, smoky solitary rooms and the work there to be highly secretive, it is tempting to say that the

kind of alchemical practice in Friedrich's laboratories was actually something else, metallurgy perhaps, or medicine. The practitioners, however, believed that they were alchemists and that what they were doing was alchemy. The market had given them access to the art, and their skills were appreciated by patrons quite willing to pay for them. Their activities were just as much a part of alchemy as were the mystical meditations of their more spiritual colleagues.

PATRONS AND THE USES OF ALCHEMY

Why did princes like Friedrich devote such substantial resources to practical alchemical projects? Historians such as R. J. W. Evans and Bruce Moran have argued convincingly that alchemy could offer a solution to the political and religious problems plaguing central Europe. As Evans noted decades ago in his exploration of Emperor Rudolf II's well-known occult pursuits, the alchemical view of nature posited a single divine order that underlay and connected the natural and the human worlds. As such, the alchemist's work in the laboratory was also work on the world, and "alchemists sought not only the regeneration of metals through the [philosophers'] stone, but also the moral and spiritual rebirth of mankind."[34] This idea held particular promise in a fractured Holy Roman Empire still reeling from the religious wars following the Reformation.[35] Bruce Moran emphasized the political side of this same coin. "The occult vision of unity and universality," he noted, "offered an intellectual balsam for religious and political confusion. As such, it became a surrogate reality, and it is in this sense that its patronage, as much at Hessen-Kassel as at other German courts, became finally a patronage of despair."[36]

Certainly alchemy appealed to some princes on these abstract (yet very real) levels. The increased appeal of alchemy just as the political and religious structure of the empire seemed to be falling apart is an important connection, and does much to explain the power of alchemical ideas. Princes also had more practical concerns, however, and alchemy addressed these as well. We can well understand why it would have appealed to princes concerned about their health, for example. Whether practitioners sought to create a panacea in the philosophers' stone or simply the newly fashionable chemical drugs vaunted by Paracelsus and his followers, alchemy certainly promised medical marvels. And few Renaissance princes would have turned down the pearls and gemstones some alchemists offered, let alone Anna Zieglerin's wintertime fruit. Renaissance princes' delight in such wonders is well-known and would have disposed them to appreciate alchemy's more opulent productions.

A number of central European princes saw even more potential in practical alchemy and understood it as a solution to the financial and mining crises afflicting their territories in the second half of the sixteenth century. Nearly constant warfare combined with Renaissance building projects and courtly splendor drained princely coffers over the course of the sixteenth century. At the same time, the rich central European mines, a fruitful source of income through the mid-sixteenth century, began to stagnate.[37] Whereas new technologies and financial investments had increased silver production in central Europe fivefold between 1460 and 1550, this growth leveled off in the second half of the sixteenth century as the balance shifted definitively toward imported American silver. Silver imports to Europe increased more than thirty-fold in sixty years, in fact, surging from 86 metric tons in the 1530s, to 1,118 in the 1570s and 2,707 in the 1590s.[38] By 1600 the golden age of central European mining had clearly come to a close.

Despite this slump, and perhaps in reaction to it, German and Bohemian princes continued to take an active interest in mining, and several territorial rulers quite actively pursued projects designed to exploit their territories' natural resources. Duke Julius of Braunschweig-Wolfenbüttel, for example, commissioned a report in 1572 on "all kinds of mountains, metals and other uses which are found in [the mining regions of] the Harz and Rammelsberg" and hired mining expert (*Bergmeister*) Hans Fischer to search the ducal territory for natural resources.[39] In addition to these kinds of exploratory projects, Julius invested heavily in his various mines, spending roughly a third of his budget on them in 1579–80, a sum justified by the fact that his mining enterprises were his largest source of income.[40] Other princes took similar measures to develop their mining industries.[41]

For these princes, practical alchemy was intimately related to the pursuit of profits through mining. Alchemical expertise, particularly that of *Scheidekunst*, or smelting, could be extremely useful in mines where difficulties in extracting precious metals from ore had caused a decline in productivity. Recall Chimia's claim in Lauterwald's text: "The minerals must choose me as well / When they want to separate themselves from others." This seems to have been the case with the mine that Bohemian magnate Vilém Rožmberk bought in Reichenstein (Lower Silesia), where the gold ore was particularly thinly dispersed and difficult to smelt. The alchemical laboratory Vilem established there immediately after he purchased the mine may well have been intended to solve this problem.[42] Two alchemists proposed similar processes to Duke Julius of Braunschweig-Wolfenbüttel in the 1570s. Caspar Uden offered a process "by which copper and silver may be separated," and Theophil Töpfer proposed a somewhat vague process for separating metals "resulting from an alchemical technique."[43] Although Uden and Töpfer were not successful in their proposals, Duke Julius clearly valued alchemy's

contribution to his mining enterprises and credited it with their renewal. Responding favorably to another proposal in 1576, Julius commented, "Like our beloved Lord and Father, we have been so involved with alchemy that we have paid dearly with thousands of thaler. Nevertheless, it has also taken us so far that for one thing, we have improved our mines during our reign, such that we now enjoy from our various mountains 480,000 gulden coins more yearly."[44]

Not only could alchemists assist princes whose ore was difficult to smelt, but they also promised either to multiply existing precious metals or to turn metals of lesser quality into gold or silver. The alchemist Georg Honauer (d. 1597) held out this possibility to Duke Friedrich I of Württemberg when he claimed to possess a process with which two men could produce one zentner (100 pounds) of gold weekly from the iron in Friedrich's iron-rich territory of Mömpelgard. ("One could also organize it like a large mine," Honauer added, "with a thousand men.")[45] Honauer arrived just as Duke Friedrich had demonstrated his commitment to developing his mining industries by announcing a reward for the location of new ore deposits. Friedrich did not hesitate to hire Honauer; he brought him to Stuttgart in 1596 under ducal protection, converted the old garden house into an alchemical laboratory, and provided Honauer with thirteen assistants. After the alchemist proved his skill in several small trials, Friedrich got down to business: he imported 25 zentner (2,500 pounds) of iron from Mömpelgard and charged Honauer to get to work.[46]

Duke Friedrich I and Georg Honauer may have hoped for unusually spectacular results, but their basic understanding of alchemy as an extremely productive and versatile art was common among central European patrons and practitioners in the decades before the Thirty Years' War. Above all, these practitioners and patrons viewed practical alchemy as a means to generate profits, whether through sales of books, recipes, processes, or the application of those processes to large-scale mining enterprises. This was primarily a utilitarian use of alchemy, aimed ultimately less at the production of broad hypotheses about the natural order than at understanding how to manipulate nature in order to make it more prolific.

At the end of the seventeenth century, Johann Joachim Becher (1635–82) would develop a much more sophisticated formulation of the relationship between alchemy and commerce that linked them metaphorically through the production and consumption common to them both. By equating the two, Becher hoped to translate his patrons' interest in alchemy into support for commercial projects in the German lands.[47] At the end of the sixteenth century, however, neither the projects nor their promoters articulated such a comprehensive view. Practical alchemists around 1600 focused their proposals on specific processes and their immediate yields rather than on large-

scale economic projects. For their part, princely alchemical schemes did not situate alchemy within a broader reconceptualization of their economies, nor did they engage yet in the global economics we associate with seventeenth- and eighteenth-century commerce.

Instead, these alchemical projects sought to employ new means in order to maintain traditional ways of generating money (such as mining). The goal — to increase the production of precious metals in a territory — was still fairly traditional, even if the means were somewhat more innovative. In this context, Ercker's comment that Duke Julius could produce "much more than a merchant" with his alchemical process may be even more revealing. Unlike Becher's equation of commerce and alchemy, which sought to engage the emperor in the commercial activities of the merchant, the practical alchemy that flourished a century earlier may have been a way to do just the opposite: find a way to improve on traditional methods of making money precisely *without* involving the empire's princes in the suspect world of the merchant. As such, the princely amalgam of alchemy and mining was a curious blend of tradition and innovation, indicative of the halting emergence of early modern commerce.

CRITIQUES OF THE NEW ALCHEMICAL COMMERCIALISM

Alchemists' participation in the world of commerce did not go unnoticed. Critics of alchemy as a whole expressed doubt about whether alchemy actually could achieve the creation of wealth it promised. At the same time, those who believed in alchemy but pursued it with more philosophical or spiritual priorities in mind attacked profit-seeking practitioners in print. Drawing on older conflicts about whether alchemists should use the art solely to make gold and silver, these critics raised a new objection about the buying and selling of alchemical secrets. In fact, they denied that alchemists with commercial tendencies were "true" alchemists at all and dismissed them as impostors and frauds. As the sixteenth century came to a close, the alchemical community seemed divided between those who believed that alchemy's objective should be the production of profit, and those who pursued alchemy as a spiritual act with the potential for the regeneration of the world.

The Protestant clergyman and rector Johannes Clajus (1532–92) was among those who were highly skeptical of alchemy altogether. In his satirical treatise, *Altkumistica, Das ist die ware Goldkunst . . . aus Mist gut Gold zu machen* (*Old-cow-manure, or, the true golden art . . . of making good gold out of manure*, 1586), Clajus expressed traditional doubts about the use of alchemy to create wealth. He used a clever play on words to contrast the practice of alchemy (*Alchemisterey*) with the traditional agricultural method of making

a living by fertilizing fields with cow manure (*Altkuhmisterey*, or "old-cow-manure-istry").[49] Clajus listed an abundance of products that could ultimately result from such a well-fertilized field: eggs, meat, milk, wool, pelts, leather, hemp oil, and flax, all of which had commercial value. In this way, he argued, the practitioners of traditional farming, or *Altkuhmisterey*, could turn manure into gold.[49]

Clajus's treatise juxtaposed this peasant *Altkuhmist* with the alchemist, setting up an opposition between the traditional agricultural livelihood and what he clearly saw as a new method: manufacturing it alchemically. Clajus rejected the possibility of alchemically manufacturing gold and feared that with so many fixated on an impossible alchemical dream, society would ruin itself. "Because just now all over this land," he wrote,

> Alchemy is growing rampant / And is wreaking havoc more and more / Many apply themselves diligently to making gold / But end up only falsifying metal / Scattering false coins all over the place. / The fact that many are seduced / as one can easily establish with examples / makes a mockery of alchemy / which is nothing but fraud.[50]

Clajus felt that alchemists were most dangerous to themselves. They wasted their money pursuing a hopeless fantasy, perhaps, like Sömmering, spending a fortune on books and materials. (Practitioners of *Altkuhmisterey*, on the other hand, would find that their fields always provided plenty.) Clajus also noted that the unlucky could face pitfalls even worse than poverty. "Many lose eyes and hands, many are beheaded, many burned," Clajus warned, hinting at several prominent alchemists who went to the gallows for failing to produce gold for their patrons.[51] Given alchemy's capacity to both impoverish and incriminate its practitioners, Clajus concluded, alchemists ought to stick to more traditional (and certain) ways of making a living, such as farming. He ended with an admonition: "This is why I recommend Altkuhmisterey . . . / With God it is certain and secure / It bears gold out of manure / it is to be tried."[52]

Proponents of the alchemical arts disagreed with Clajus's denunciation, of course, and wrote treatises praising alchemy's virtues. Many of alchemy's advocates found themselves walking a fine line, however, with regard to criticisms like Clajus's. As much as they rejected arguments about alchemy's futility, a number of alchemists found themselves sympathetic to concerns about alchemists' participation in the marketplace. Rejecting both the use of alchemy solely to create gold and silver and the practice of selling alchemical knowledge for money, critical alchemists increasingly argued that by definition, practitioners engaged in alchemy's commercial dimension were not "true" alchemists at all.

The notion that alchemy was about much more than gold and silver had a long history; for centuries some practitioners of the art had struggled to distance themselves from what they saw as the corruption of alchemy. In the early modern period, Paracelsus insistently reminded his readers that he used the term "alchemy" to mean a technique, usually medicinal, not the preparation of gold or silver.[53] The Paracelsian Alexander Lauterwald expressed these sentiments as well in two treatises which responded directly to Clajus: *Widerlegung der Altkuhmisterey* (*Refutation of Altkuhmisterey*, 1597) and *Colloquium Philosophicum* (*Philosophical Colloquium*, 1597). In the *Colloquium Philosophicum*, a dialogue between the three sisters Chimia, Sapientia, and Natura and a young novice in the alchemical arts, Lauterwald's interlocutor Chimia warned the boy to beware:

> If you hear someone openly say / . . . he wants to make silver and gold / you mustn't give him any money, / for what does such a man need? / He should earn his own living. / You mustn't seek gold; / people will easily judge you. / Those lads [who do] are the bad seeds / whom I named before. / Many honorable men have been cheated by them / parted from their things / finally separated from their goods and possessions; / Only then have they realized / that such lads deal in tricks. / And so seek the truth / wherein you will find me / you find me also in my dear children / they are the true philosophers.[54]

Lauterwald's Chimia challenged the novice with a higher calling instead. She explained that the alchemist's true purpose was to use the philosophers' stone to heal all bodies, "human, animal and metallic," of the worldly corruption that followed the Fall of Adam and Eve. In this sense, alchemy was spiritual work, aimed at the regeneration and ennobling of a corrupt and fallen world.[55]

Although the vociferousness with which spiritual and philosophical alchemists tried to distance themselves from gold-making reached a crescendo around 1600, their objections were hardly unique to the sixteenth century.[56] Beginning in the 1590s, however, critics began to react to the burgeoning market in alchemical goods and princes' increasing interest in alchemy's commercial application. In response, critical tracts began to focus on a new issue: the sale of alchemical recipes and processes for profit. Lauterwald's treatise reflects this trend as well. He denounced market-oriented alchemists (or "process-sellers," as another observer called them[57]) as frauds who seduced others with alchemy's promise of riches and eternal life only to trick them out of their money. Again speaking through Chimia, Lauterwald issued a stern warning to stay away from such impostors.

> If such a visitor comes to you / Of whom you have heard before and / Who claims that he can make gold / Ask him what kind of pay he wants. / He will come finely dressed, / Finished off with a golden visage. / He will require three hundred ducats / For this he will counsel / A tincture that spews a thousand. / Stay away from such a wicked type . . . / This is what I want to say to you / You mustn't support processes.[58]

Lauterwald simply assumed that anyone who sold alchemy's secrets was a fraud because the "true" alchemist would never do such a thing. Chimia's words reflect a deep suspicion that most practitioners simply wanted to cash in on alchemy's appeal to wealthy princes.

The Leipzig-born physician and mystical alchemist Heinrich Khunrath (1560–1605), best known for the engraving of the alchemist in his Laboratory-Oratory that appeared in his *Amphitheatrum Sapientiae*, took a slightly milder approach.[59] In a nineteen-page "Heartfelt warning and admonition by a faithful devotee of the truth to all true devotees of the natural transmutory alchemy, which one need keep an eye on because of the villainous grip of the fraudulent malicious chymists," Khunrath merely issued a caveat emptor.[60] "If a goldbeetle flies up to you and says that he can make silver and gold and wants to teach you how," Khunrath warned, "do not believe him quickly and easily; because it is not as mean an art as many let themselves dream it to be."[61] Khunrath certainly did not spare harsh words for "the goldbeetle guild of villans and ill-intentioned and fraudulent alchemists," but he did put the burden not to be tricked on the buyers of alchemical secrets.[62] Khunrath's remedy was to expose the sleights of hand and tricks he believed the impostors used to dupe potential backers. A well-informed buyer, he evidently felt, would make sounder decisions in the alchemical marketplace and stay away from common alchemists.

The physician and occult philosopher Michael Maier (1569–1622) offered a much deeper and more nuanced critique of commercial alchemy. Like Lauterwald and Khunrath, Maier believed that alchemy was fundamentally a spiritual art because it dealt with God's greatest secrets, and he disapproved of those with lesser interests.[63] In his 1616 *Examen fucorum pseudo-chymicorum* (Swarm of drones, or a critical examination of the pseudo-chymists),[64] Maier publicized his vitriolic attack on those he considered "pseudo-chymists." His "four marks of the false alchemists" wove together moral, intellectual, and commercial arguments into a damning denunciation of practical alchemists, concluding that "such men are very harmful both for the state and for Chymica."[65]

The second of Maier's four marks of the impostor explicitly took up the issue of commercial exchange, imparting his disapproval of practical alchemists who traded in the marketplace. Like Lauterwald, Maier registered

this censure by defining those who sold alchemical knowledge as false alchemists. "It is an unmistakable sign of the pseudo-chymicus that he wants to sell gold for gold, something uncertain as a fact and something priceless for very little," Maier reasoned. In particular, he questioned the very idea of alchemy as a commodity by focusing on the issue of prices:

> It goes against all reason that someone who really had really mastered this great art, tested over and over again in experiments, would want to sell this knowledge to another for a piece of bread or a bit of gold. If he really doesn't possess it, then it is as if he had sold wind and empty words for money. If the latter is the case, then the scoundrel receives too much money for the wind, and the buyer is cheated. If the former is the case, then the seller is cheated."[66]

If a practitioner truly possessed the secrets of alchemy, in other words, why would he or she sell it for a bit of gold, for surely it would be worth much more? If, on the other hand, the supposed alchemist sold only empty promises, then a bit of gold was far too high a price.[67] In Maier's view, alchemy was either priceless or worthless.

Beneath Maier's discussion of the logic of selling alchemical secrets, one can detect a broader agenda. The rest of his treatise fired moral, epistemological, and philosophical salvoes at the folly of those who thought they could become alchemists with a little training, almost as easily as one could become a goldsmith or pharmacist. Maier viewed alchemy as a sacred art, a lifelong project to understand God's mysteries, which required learning, piety, and years of hard work. He was troubled by the popularization of alchemy and what he saw as its dilution to the point of not being alchemy at all. In the context of commerce, however, what is striking about the *Examen fucorum pseudo-chymicorum* is that Maier chose to articulate this point in the language of profit and commercial exchange. As much as he felt that the market for alchemical goods was responsible for the proliferation of a type of alchemy of whose goals and practices he despised because it created shoddy practitioners and the patrons to support them, he also knew that that market was both vibrant and undeniable. Unable to argue it out of existence, he chose instead to attack it on its own terms, exposing what he saw as the flaws of a system that viewed alchemy in terms of profits and prices.

THE VALUE(S) OF ALCHEMY

The critiques of alchemists like Maier, Lauterwald, and Khunrath reveal a fundamental divide in the community of alchemical practitioners about the

value of their art. Those who purchased and peddled alchemical knowledge in the decades around 1600 operated in a world in which alchemical value was defined in terms of utility and profit. Practitioners like Sömmering purchased books and recipes, hoping in turn to sign contracts with patrons and sell acquired knowledge for thousands of thaler. Patrons like Duke Julius of Braunschweig-Wolfenbüttel, in turn, purchased this kind of alchemical knowledge, investing their fortunes in alchemy in order to multiply the natural resources in their territories. Such practitioners and patrons may have appreciated more intellectual or spiritual aspects of alchemy as well, of course, but these considerations rarely entered into their contracts, laboratories, or alchemical work. These were evaluated in terms of how useful and productive buyers perceived the alchemy to be. Critics like Michael Maier, on the other hand, operated in a different value system. They too circulated in courtly circles and depended on princely patronage, but as alchemists they located their own worth elsewhere, in their status as pious, learned men with a deep understanding of God's mysteries. For them, recipes or processes isolated from that larger learning were both impossible and, ultimately, worthless.

The irony was that, as much as philosophical and spiritual alchemists wished to remove alchemy from the marketplace, they ultimately could not. Even if they did not directly compete with their more practically minded colleagues for contracts, alchemists like Michael Maier did perceive them as competition for the right to define what the "true" alchemy was. For even if philosophical alchemists scorned practical alchemists as frauds and impostors, princes did not—and noble support gave legitimacy to practical alchemy. As the sixteenth century came to a close, in fact, practical alchemy seemed to be gaining more and more princely support as princes placed their fortunes in the hands of its practitioners. The sudden appearance of treatises like Maier's *Examen fucorum pseudo-chymicorum* testifies to the vitality he and others ascribed to this new breed of alchemy, and the extent to which they feared its triumph. In the end, of course, they were right: enthusiasm for purely transmutational alchemy would eventually dissipate and come to be mocked as it is today. This would take centuries, however; even in 1796 a contributor to a German newspaper would declare that "thousands of hands and minds" were still at work on alchemy in the Holy Roman Empire.[68] In the sixteenth and even early seventeenth centuries, both strains of alchemy—one commercial, one philosophical—might have claimed the right to define whether alchemy was to be a pious natural philosophy or a useful practice immersed in the expanding world of early modern commerce.

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1. See, for example, B. J. T. Dobbs, *The Foundations of Newton's Alchemy or, "the Hunting of the Green Lyon"* (Cambridge: Cambridge University Press, 1975); R. J. W. Evans, *Rudolf II and His World: A Study in Intellectual History* (Oxford: Oxford University Press, 1973); Bruce Moran, *The Alchemical World of the German Court: Occult Philosophy and Chemical Medicine in the Circle of Moritz of Hessen (1572–1632)* (Stuttgart: Franz Steiner Verlag, 1991).

2. One important exception to this trend is Pamela Smith, *The Business of Alchemy : Science and Culture in the Holy Roman Empire* (Princeton, N.J.: Princeton University Press, 1994).

3. Of course, students of alchemy had always spent money on books. Roger Bacon (c. 1215–after 1292) noted as much in his 1267 *Opus Tertium* (Third work) when he wrote, "Through the twenty years in which I laboured specially in the study of wisdom, careless of the crowd's opinion, I spent more than two thousand livres in these pursuits on occult books [*libros secretos*]." As cited (and translated) in E. J. Holmyard, *Alchemy*, 2nd ed. (Baltimore, Md.: Penguin Books, 1968), 119.

4. William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J.: Princeton University Press, 1994), 125–126.

5. Peter Kertzenmacher, *Alchimia Das ist alle Farben, Wasser, Olea, Salia, und Alvmina, damit mann alle Corpora Spiritvs unnd Calces Prepariert, Sublimiert unnd Fixiert Zubereyten : und wie man diese ding nutze, auff dass Sol und Luna werden möge : Auch von Soluieren unnd Scheydung aller Metall, Polierung allerhandt Edelgestein, fürtrefflichen Wassern zum Etzen, Scheyden unnd Soluieren: Und zuletzt wie die gifftige Dämpff zuuerhüten, ein kurtzer bericht* (Frankfurt am Main: C. Engenolff's heirs, 1570), iv. On the various editions of Kertzenmacher's text and their differences, see Eamon, *Science and the Secrets of Nature*, 114–133.

6. Eamon, *Science and the Secrets of Nature*, 126.

7. Philipp Sömmering's testimony, 1 Alt 9, Nr. 311, fol. 14ff. Niedersächsisches Staatsarchiv Wolfenbüttel (hereafter NStA Wolfenbüttel). For printed accounts of Sömmering's life, see Albert Rhamm, *Die betrüglichen Goldmacher: am Hofe des Herzogs Julius von Braunschweig: Nach den Processakten* (Wolfenbüttel: Julius Zwißler, 1883), 3–5, and Jost Weyer, *Graf Wolfgang II. von Hohenlohe und die Alchemie: Alchemistische Studien in Schloß Weikersheim, 1587–1610*, ed. Stadtarchiv Schwäbisch Hall, the Hohenlohe-Zentralarchiv Neuenstein and the Historischen Verein für Württembergisch Franken, (Forschungen aus Württembergisch Franken, 39) (Sigmaringen: Jan Thorbecke Verlag, 1992), 283–285.

8. *Librum Isaacij* and *Hexameron Bernardij*. I have been unable to identify these books and their authors, although I assume that the latter were hexameral writings attributed to Bernardus of Treves (fourteenth century). On Bernardus of Treves, see William Newman, "Bernardus Trevirensis," in *Alchemie: Lexicon einer hermetischen Wissenschaft*, ed. Claus Priesner and Karin Figala (Munich: C. H. Beck, 1998), 78. The *Book of Isaac* may refer to the writings of "Isaac Hollandus," a possibly mythical alchemist whose writings first appeared in the 1560s. See Julian Paulus, "Hollandus, Isaac and Johann Isaac," in *Alchemie*, ed. Priesner and Figala 181.

9. Philipp Sömmering's testimony, 1 Alt 9, Nr. 311, fol. 14ff. NStA Wolfenbüttel. For printed accounts of Sömmering's life, see Rhamm, *Die betrüglichen Goldmacher*, 3–5, and Weyer, *Graf Wolfgang II*, 283–285.

10. William Eamon makes this point in *Science and the Secrets of Nature*, chap. 1.

11. Clearly Lazar Ercker did not identify himself as an alchemist; in fact, as Pamela Long correctly has pointed out, he is quite critical of alchemy in his published treatises. In practice,

however, Ercker's projects seem little different from those of self-identified alchemists. Compare his process here, for example, to Hirschenberg's below. The lines between metallurgy, mining, and practical alchemy are extremely difficult to draw in this period. One person may call a particular process alchemy, and another may choose not to use the term. I take the broadest possible understanding of alchemy, one which is defined by practices rather than the rhetoric that often appeared in printed treatises. On Ercker and alchemy, see in particular Pamela O. Long, "The Openness of Knowledge: An Ideal and Its Context in 16th-Century Writings on Mining and Metallurgy," *Technology and Culture* 32, no. 2 (1991): 318–355.

12. Lazar Ercker to Herzog Julius in Wolfenbüttel, 3 May 1585, 1 Alt 9, Nr. 394, fol. 1–2, NStA Wolfenbüttel.

13. Ibid., fol. 1.

14. Ibid., fol. 2.

15. Petr Hlavsa's exact dates are unknown, though he did serve as mintmaster to the kingdom of Bohemia from 1553 to 1561. See Václav Březan, *Zivoty Posledních Rožmberků*, 2 vols., ed. Jaroslav Panek (Prague: Svoboda Praha, 1985), 283, 701, 801.

16. One Loth = approximately 14.62 g, thus the amount of metal involved in this transaction was actually quite small: 16 Loth = 233.85 g. On Hirschenberg, whose exact dates are unknown, see Joachim Telle, "Der Alchemist im Rosengarten. Ein Gedicht von Christoph von Hirschenberg für Landgraf Wilhelm IV. von Hessen-Kassel und Graf Wilhelm von Zimmern," *Euphorion* 71 (1977): 283–305.

17. Petr Hlavsa to Vilém z Rožmberku (alias Wilhelm von Rosenberg), 18 January 1574, Rožmbersky roddiny archiv 25, Státni oblástní archiv Třeboň (hereafter SOA Třeboň), Czech Republic.

18. On Polhaimer, see Weyer, *Graf Wolfgang II.*, 228–271 and his "Der 'Goldmacher' Michael Polhaimer—Alchemistischer Betrüger am Hof des Grafen Wolfengang II. von Hohenlohe," *Beitrage zur Landeskunde. Regelmäßige Beilage zum Staatsanzeiger für Baden-Württemberg* 4 (1993): 7–11.

19. For a description of this contract, see Rhamm, *Die betrüglichen Goldmacher*, 5. Sömmering left Gotha in the chaos of war and Reformation politics, abandoning his obligations, while Scherdinger subsequently took a new post as a pastor elsewhere. In 1571, however, Sömmering signed another contract with Duke Julius of Braunschweig-Wolfenbüttel.

20. Cost- and risk-sharing arrangements like these worked to the benefit of both parties involved. By giving up a share of their future profits, alchemists gained the initial investment they needed to put their knowledge to work (not to mention, of course, the social and political benefits that accompanied such a position at court). For their part, princes could hope to earn back their initial capital outlay once the alchemical work was under way.

21. Alexander Lauterwald, *Colloquium Philosophicum. Von der warenn Chimia, Sapientia, vnd Natura rerum, Wie die von menniglichen vnd allen Liebhabern der Kunst von aller Sophisterey vnd betriegery/mag vnterschieden vnd verstanden werden. Alles zu Gruendlicher vnd warhafftiger widerlegung des groben Phantasierens M. Johan Claij/Bengellebischem Pfarherrs/der durch die Altkumisterey/andere lerer Gold machen/Vnd also das herrliche/vnd verborgenste Geheimnis/so vnter allen Natuerlichen dingen/vnd fuertrefflichsten Gaben Gottes/sehr wenigen bekant vnd offenbaret ist/aus lauterm vnuerstand vnd grobheit/dem stinckenden Kuhemist vorzichen thut etc.* (Cologne: Heinrich Netessem, 1597). Lauterwald's dates are unknown.

22. Ibid., fol. A4v.

23. In exchange, Wagenmann received 4,000 gulden, which he pledged to pay back should he fail. Agreement between Michael Heinrich Wagenmann vom Hoff and Duke Friedrich, Stuttgart, 23 December 1598, Bestand 47 (Alchemie Sachen), Büschel 3, Number 6, Hauptstaatsarchiv Stuttgart (hereafter HStA Stuttgart).

24. Melchior Hornug to Vilém z Rožmberkŭ, 4 April 1585. SOA Třeboň. On potable gold (*aurum potabile*), see Lawrence Principe, "Aurum potabile," in *Alchemie*, Priesner and Figala, ed. 66, and the bibliography there.

25. "Präparation des Stein der Weisen, von A. M. Ziegler, in eigenhändiger Anschrift des Hzg. Julius," 1 April 1573, 1 Alt 9, Nr. 308, fol. 52–70, NStA Wolfenbüttel.

26. Ibid., fol. 64–65.

27. This double meaning makes sense since, in Paracelsian terms, the healing of the body was analogous to the healing of base metals; in both cases, a chemical medicine was necessary.

28. For an account of Bragadino's life, see Ivo Striedinger, *Der Goldmacher Marco Bragadino* (Munich: Theodor Ackerman, 1928). Also Hatto Kallfelz, "Der zyprische Alchimist Marco Bragadino und eine florentiner Gesandtschaft in Bayern," *Zeitschrift für bayerische Landsgeschichte* 31, no. 2 (1968): 476–500, and Kallfelz's article "Bragadino, Marco," *Dizonario Biografico degli Italiani,* 13: 691–694.

29. Marco Bragadino, Michael Sendivoj, Edward Kelley, and Heinrich Müller von Mühlenfels are examples of the former, while Anna Zieglerin and Philipp Sömmering are instances of the latter. See Hermann Kopp, *Die Alchemie in älterer und neuerer Zeit* (Heidelberg: Carl Winter's Universitätsbuchhandlung, 1886).

30. These included an "oil from gold" (the recipe for which was to be found in the ducal apartments (in "a special table in which all the alchemical things are together"), a "salt from gold," an *aurum potabile*, the coagulation of a "red water which is supposed to have come from Prag," a process for "finishing" gold learned from another alchemist named Thurnheuser (Leonhard Thurneisser?), a *praecipitat* from Müllenfels, one of the duke's former alchemists who had been hanged two years earlier for fraud and *lèse-majesté*, a vial to be set in the fire for two years, eventually to yield a projection of gold, and one last, somewhat mysterious, "special process." Inventory from 28 January–3 February 1608, Bestand 47, Büschel 9, HStA Stuttgart.

31. Ibid.

32. Ibid. (These salary figures are also listed in the 1608 inventory.)

33. Ibid.

34. Evans, *Rudolf II and His World*, 201.

35. Ibid., 276.

36. Moran, *The Alchemical World of the German Court*, 25.

37. See Long, "The Openness of Knowledge"; Phillippe Braunstein, "Innovations in Mining and Metal Production in Europe in the Late Middle Ages," *Journal of European Economic History* 12 (1983): 563–591; Hans-Joachim Kraschewski, *Wirtschaftspolitik im deutschen Territorialstaat des 16. Jahrhunderts: Herzog Julius von Braunschweig-Wolfenbüttel*, ed. Prof. Dr. Ingomar Bog (Neue Wirtschaftsgeschichte, 15) (Cologne and Vienna: Böhlau Verlag, 1978); Danuta Molenda, "Technological Innovation in Central Europe between the XIVth and the XVIIth Centuries," *Journal of European Economic History* 17 (1988): 63–84.

38. Richard Bonny, *The European Dynastic States, 1494-1660* (Oxford: Oxford University Press, 1991), 420.

39. Kraschewski, *Wirtschaftspolitik im deutschen Territorialstaat*, 127–128.

40. Ibid., 157. The same year, Julius received 42 percent of his income from his mining enterprises in Rammelsberg and the Harz (152).

41. Duke Friedrich of Württemberg, for instance, displayed his desire to exploit the natural resources in his territories in 1596 when he announced a reward for the discovery of ore deposits in his lands. The following year, Friedrich established the city of Freudenstadt and founded a silver mine nearby. In Bohemia, the Czech magnate Vilém Rožmberk bought a silver mine in Reichenstein (in Czech Rychleby — today Liberec — in Polish Złoty Stok, located

in Lower Silesia) and immediately established an alchemical laboratory there. See Václav Březan, *Životy Posledních Rožmberků*, 703.

42. Five different methods had been tried earlier in the sixteenth century to deal with this, which may explain why the mine was bankrupt by the end of the century. See Danuta Molenda, "Technological Innovation in Central Europe," 75. Also Březan, *Životy Posledních Rožmberku*, 703.

43. On Uden: "Schreiben vom August 1576, Unterschrift und Datum fehlen," 2 Alt 24, NStA Wolfenbüttel. On Töpfer: "Schreiben des Theophil Töpfer an Sander vom 5.2.1575," Fach 2a, 10, Oberbergamt Clausthal.-Zellerfeld Archiv des Oberbergamtes. As quoted in Kraschewski, *Wirtschaftspolitik im deutschen Territorialstaat*, 159–160.

44. "Neigung des Herzogs Julius zur Alchemie; Befehl an die Beamten," 5 June 1576, 2 Alt 24, NStAW. As quoted in Kraschewski, *Wirtschaftspolitik im deutschen Territorialstaat*, 159. When Duke Julius hired Sömmering (after he had left Gotha and his employment with Duke Johann-Friedrich there), the alchemist signed a contract that reflects this close link between mining and alchemy: Sömmering promised not only to teach Julius how to make the philosophers' stone, but also to increase the yield of Julius's mines to 200,000 thaler a year. Rhamm, *Die betrüglichen Goldmacher*, 8–9.

45. Georg Honauer to Emperor Rudolf II, 5 January 1597, Bestand 47, Büschel 1, Number 10 (part 1, unpaginated), HStA Stuttgart.

46. "Documents regarding the trial of Georg Honauer," Bestand 47, Büschel 1–2, HStA Stuttgart. Similarly, Alchemists Moritz Lam and Georg von Minden offered Duke Julius of Braunschweig-Wolfenbüttel a process in 1576 "by which copper can be made from the Rammelsberg lead." "Die angegeben Neue Alchimisten, Moritz Lam und Georg v. Minden betr., Vernehmungsprotokoll vom 6.6.1576," 2 Alt 24, NStA Wolfenbüttel. As quoted in Kraschewski, *Wirtschaftspolitik im deutschen Territorialstaat*, 159.

47. Pamela H. Smith, "Curing the Body Politic: Chemistry and Commerce at Court, 1664–70," in *Patronage and Institutions: Science, Technology, and Medicine at the European Court, 1500-1750*, ed. Bruce T. Moran (Rochester, N.Y.: Boydell Press, 1991), 195–209, and Smith, *The Business of Alchemy*.

48. I have looked at the later 1616 edition: Johann Clajus, *Altkumistica: Das ist / Die ware Goldkunst / aus Mist durch seine Operation vnd Process gut Goldt zu machen / Wider die betrieglichen Alchymisten vnd vngeschickten vermeinten Theophrastisten von Herrn Johanne Clajo beschrieben: Neben angehencktem Special Bericht / von allerhand geheimen vnd subtilen raenken vnd Handgriffen / dadurch die Arg Chymisten vnnd des uebrigen Geldes fein artig zu endledigen / und an statt der verhofften gueldenen Berge Aschen / Kohlenstaub vnd den lehren Beutel zulassen wissen. Auch wie mit dergleichen Kuenstlern vnd Gabalierern zu verfahren seige. Mennigklichen zur Nachrichtung und Warnung zusammen gebracht / Durch Aletophilum Parrhesiensem*, 3rd ed. (Mülhausen: Johann Stangen, 1616).

49. "A commendable art is here described / Which became widely accepted / Long ago among the ancients / From the beginning and the Creation / [This art] is called "old-cow-manure" (*Altkumisterey*) / In which there is no sophistry / No false dealings nor fraud / Just that which one turns up with a plow / On a field which is / well-fertilized and enclosed." Clajus, *Altkuhmistica*, "Vorrede" [unpaginated].

50. Ibid.

51. Ibid.

52. Ibid.

53. See Massimo Luigi Bianchi, "The Visible and the Invisible: From Alchemy to Paracelsus," in *Alchemy and Chemistry in the 16th and 17th Centuries*, ed. Piyo Rattansi and Antonio Clericuzio (Dordrecht: Kluwer Academic, 1994), 17–50.

54. Lauterwald, *Colloquium Philosophicum* [unfoliated, 16r–v].

55. Ibid. [unfoliated, 23v.]

56. See Berend Strahlmann, "Chymisten in der Renaissance (16. Jahrhundert)," in *Der Chemiker im Wandel der Zeiten; Skizzen zur geschichtlichen Entwicklung des Berufbildes*, ed. Eberhard Schmauderer (Weinheim: Verlag Chemie, 1973), 47–55.

57. Michael Maier, *Examen fucorum pseudo-chymicorum detectorum et in gratiam veritatis amantium succincte refutatorum* (Frankfurt: printed by Nicolai Hoffmann, published by Theodor de Brij, 1617), 23. Reprinted (and translated into German) in Wolfgang Beck, "Michael Maiers Examen Fucorum Pseudo-Chymicorum—Eine Schrift wider die falschen Alchemisten" (Ph.D., Fakultät für Chemie, Biologie und Geowissenschaft der Technischen Universität München, 1992).

58. Lauterwald, *Colloquium Philosophicum* [unfoliated, 26–26v].

59. On Khunrath, see Elmar Gruber's introduction to *Vom Hylealischen, das ist, Pri-materialischen catholischen oder allgemeinen natürlichen Chaos, der naturgemässen Alchymiae und Alchymisten.* (Magdeburg, 1597; reprint, Graz: Akademische Druck- und Verlagsanstalt, 1990), v–xix.

60. This text, "Wahrnungs-Vermahnung an alle wahre Alchymisten, sich vor den betrügerischen Arg-Chymisten zu hüten," is appended to his *Vom Hylealischen, das ist, Pri-materialischen catholischen oder allgemeinen natürlichen Chaos, der naturgemässen Alchymiae und Alchymisten* (Magdeburg, 1597).

61. Khunrath, *Vom Hylealischen*, 268.

62. Ibid., 286.

63. See Karin Figala and Ulrich Neumann, "'Author Cui Nomen Hermes Malavici': New Light on the Bio-Bibliography of Michael Maier (1569–1622)," in *Alchemy and Chemistry in the 16th and 17th Centuries*, ed. Piyo Rattansi, and Antonio Clericuzio (Dordrecht: Kluwer Academic, 1994), 138–139.

64. Michael Maier, *Examen fucorum pseudo-chymicorum.*

65. Ibid., 10.

66. Ibid., 22.

67. "Maier even cited the law to support his point: "The Civil Code permits people doing business to haggle with one another while buying and selling, but not that more than one and a half times the true worth [of the wares] be paid or asked . . . Regarding this, see the commentary to the section [of the Civil Code] regarding buying and selling. With regard to the wares of pseudo-chymici, nothing is in proportion, because they offer only words and promises for gold. How much empty wind must one accept for the equivalent of a gold drachma, is impossible to determine. In sum: he who touches tar gets dirty hands, and he who gets involved with these people only ends up with an empty purse." Maier, *Examen fucorum pseudo-chymicorum*, 22

68. *Kaiserlich Privilegirter Reichs-Anzeiger* (Gotha), 8 October 1796 (Num. 234), col. 6095.

Time's Bodies

Crafting the Preparation and Preservation of Naturalia

HAROLD J. COOK

Scientific investigation deals with the secular world: the world of time. Scientists study manifestations of the universe as they unfold. Time may be the fourth dimension, but it is so important as to commonly become one of two axes on graphs and charts. Consequently, many of the methods employed by investigators of nature attempt to slow or quicken events. In recent decades, some of the most famous visual examples of this method include serial photographs of movement, slow-motion films of various behaviors too quick to be observed with the eye, or fast-forward films of slow transformations. In the seventeenth century, studies such as William Harvey's on generation involved the serial examination of fertile chickens' eggs and does' uteruses; his even more famous discovery of the circulation of the blood equally involved vivisectional techniques that slowed the heartbeat and pulse to events that could be seen with the naked eye. Some of the important investigations into the material structures of animal bodies carried out in the seventeenth-century Netherlands also had their roots in attempts to alter the processes of ordinary time, especially those associated with decay. The consequences of such trials proved to yield unexpected results, in making visible structures that could not otherwise be ascertained.

TIME'S VALUE: ACCUMULATION, PRESERVATION, AND THE FUTURE

Most historical discussion of changing concepts of time has focused on the development of a sense of its uniformity. Time may be an indivisible wave or a composition of streaming quanta, but in either case the principle that it is uniform, allowing one moment to be compared to another, is fundamental, even in an Einsteinian universe where the speed of matter can "slow" or "accelerate" the time of one object in relation to another. It was famously

the invention of mechanical timekeepers that conveyed the view that time is uniform. The sense that time changes with the seasons, with one's age, with peace or war, during moments of stress or bliss, accords with human felt experience. Classically, night and day were divided into twelve parts which varied with the season: the hours of night were longer in the winter, whereas the hours of light were longer in the summer. An advantage of hourglasses and water clocks is that they could be easily altered to accord with such variations. But mechanical clocks moved steadily, invariably (aside from mechanical inconsistency), dividing the day into equal hours. Now it was the night or day that changed according to the hour, not the hour that altered according to the light. Clocks quickly made their appearance in the towers of guildhalls and other municipal buildings, striking the hours to regulate commerce and other activities of large numbers of people: workers in the Low Countries had been complaining of "working to the clock" from at least the fourteenth century.[1] By the lifetime of Galileo and Descartes, both natural philosophers and musicians could take the uniform nature of time for granted, "timing" events according to regularized beats.[2] As Norbert Elias put it, "The significance of the emergence of the concept of 'physical time' from the matrix of `social time' can hardly be overrated."[3]

In the same period, however, another sense of the relationship between time and human life that had importance for the development of investigations into medicine and natural history: a growing sense that new methods of using time could bring material good. The ways of life developing among early modern capitalists helped to make questions of manipulating the ordinary processes of time seem natural. Capitalist forms of economy depended not only on drawing attention to the rapid passage of time, but also on making work more regularized. The Dutch financial world also depended on new methods of commerce that extended time: long-term arrangements. As a world of markets was being transformed into a world market, "the beating heart of the Dutch economy" was its "entrepôt function." That is, the Dutch Republic functioned as a kind of clearinghouse, to which surplus goods were shipped from all over the world for exchange and redistribution. The goods (and their abstractions in the form of bills of exchange) were traded daily at the Amsterdam Exchange (*Beurs*) rather than at periodic fairs, making it "a mustering field not only for the coincidental surplus production . . . but also for information" about commodities and exchanges worldwide, helping to stimulate collective decisions by merchants on the allocation of capital.[4] Moreover, not only the commodities themselves, but their future worth, could be bought or sold in the form of "stocks," which were paper representations of accumulations of material things. Accumulation of inventory for later (sometimes much later) sale allowed the universal principle of "buy low and sell high" to operate over the

middle and long term: items could be kept back from the market when they were otherwise too plentiful, and sold when demand increased. Inventory investment therefore reduced and spread out financial risk, making trade more predictable, and allowing for stabler calculation of future income and expense.

Inventory investment also required that goods set aside for future use or sale made it into the future in good condition. The building boom in dock- and canal-side warehouses is the clearest sign of the new form of merchant capitalism: here nutmeg or tea, there Persian rugs or Chinese silks, were collected, itemized, and assigned an estimated value for the market. In the warehouse, goods could be safeguarded and stored in a manner that prevented decay. Nutmeg, for instance, was shipped back from the Indies dusted with lime. Some other very valuable fruits came preserved in sugar. Salting and pickling kept other fish, meat, and vegetables from putrefaction. Most other goods could simply be dried and kept dry. It was this combination of methods of accumulation, preservation, and calculation of future value that allowed the merchant capitalists of the period to flourish. For instance, the Dutch East India Company (VOC) was able to manage the price of cloves by accumulating and preserving the spice in its warehouses. When the price of cloves fell in 1623, they held back cloves from the auctions to drive the price back up; when the price was so high that the English broke into the Dutch monopoly, they resorted in turn to dumping to drive the English out. With the accumulation and storage of commercial goods, therefore, a "certain measure of control over the prices" could be achieved, which together with "the concentration of the East India trade in the intimately connected London and Amsterdam markets must have meant a greater transparency of the market."[5]

As the simple example of cloves illustrates, "investing in inventory [was] crucial to a smooth functioning of the market." The permanent staple market that developed in places like Amsterdam and Rotterdam served to concentrate supply and demand, which "reduced the commercial risk, so that the cost price decreased. As supply was less regular than sales, prices fluctuated. These price fluctuations offered the prospect of future profits and thus stimulated stockpiling which, in turn, had a stabilizing effect on the price." Holland consequently became "a central storehouse and exchange" for the world market. "And inventory investment was—as already indicated—at the very heart of the Dutch entrepôt trade, which in turn was the focal point of the commercial expansion of the Dutch economy."[6] In short, inventory investment helped to create stability in "the market," hence increasing confidence in it, while growing confidence in turn helped to lower interest rates and raise the amount of available credit for more investment in exchange and accumulation. The calculation and sale of future value gave rise to new forms of material life, with ramifications for intellectual culture as well.

Like the developing world market, the investigation of nature depended on the transportation of information and specimens back to the home metropolis. There collections were accumulated, housed, and preserved, inventories were taken and sometimes published, and redistribution of the value-added information and objects occurred. The ways of life that so valued the accumulation of bulk commodities also valued the accumulation of unique objects, whether works of art or nature. Among the items brought back to the Dutch entrepôt from all over the world were natural rarities and curiosities of all sorts. These things at first tended to be one-of-a-kind, or at least scarce, objects, brought back in the bags of seamen or the chests of officers and merchants. Other specimens were cultivated in botanical gardens. Over time, a steady trade in *naturalia* developed, with a few brokers even buying up objects at dockside and later selling them to collectors. In short, many people began to collect various kinds of objects from nature, although they placed them not in shelters by the docks but in rooms in their homes: the "curiosity cabinets" of burgers, physicians, magistrates, and nobles (fig. 9.1). As in business, too, the collectors of *naturalia* kept detailed inventories of what they had. To make their collections more valuable, they tried to fill them out with new specimens, and they bought books describing the collections of others as a way of substituting for what they could not acquire directly. The accumulation and warehousing of material objects—investment in and preservation of inventory—was part of the creation of value for both naturalists and merchants.

In the sixteenth and early seventeenth century, most objects kept in curiosity cabinets had to be dried. Inventories of later sixteenth- and early seventeenth-century cabinets make this clear. For instance, one of the earliest cabinets of natural history and art assembled in the Netherlands, by Bernardus Paludanus (Berent ten Broecke), contained fruit, grains, and woods from the tropics, skins with feathers prepared from many birds (such as the bird of paradise of New Guinea), many species of fish and reptiles, the horns of a variety of animals, insects, shells, corals, types of earths, stones, minerals, marbles, precious stones, coins, medals, weapons, clothes and other objects used by "savages" and foreigners, objects of art done in ivory, rare woods, precious metals, mummies and funerary furnishings from Egypt, and so on.[7] Perhaps the fruits were pickled or preserved in sugar as well as dried; some of the skins were tanned; everything else could have been kept dried. In another example, the first inventory of the natural history collection assembled at Leiden University shows that it contained skeletons and diverse bones of humans, animals, birds, fish, and other items such as horns; rarities such as mummies and their parts, seven stones surgically removed from the bladder of Joannes Heurnius (the first medical professor of Leiden), a stone from the kidney of a young girl, and so forth; various lists and

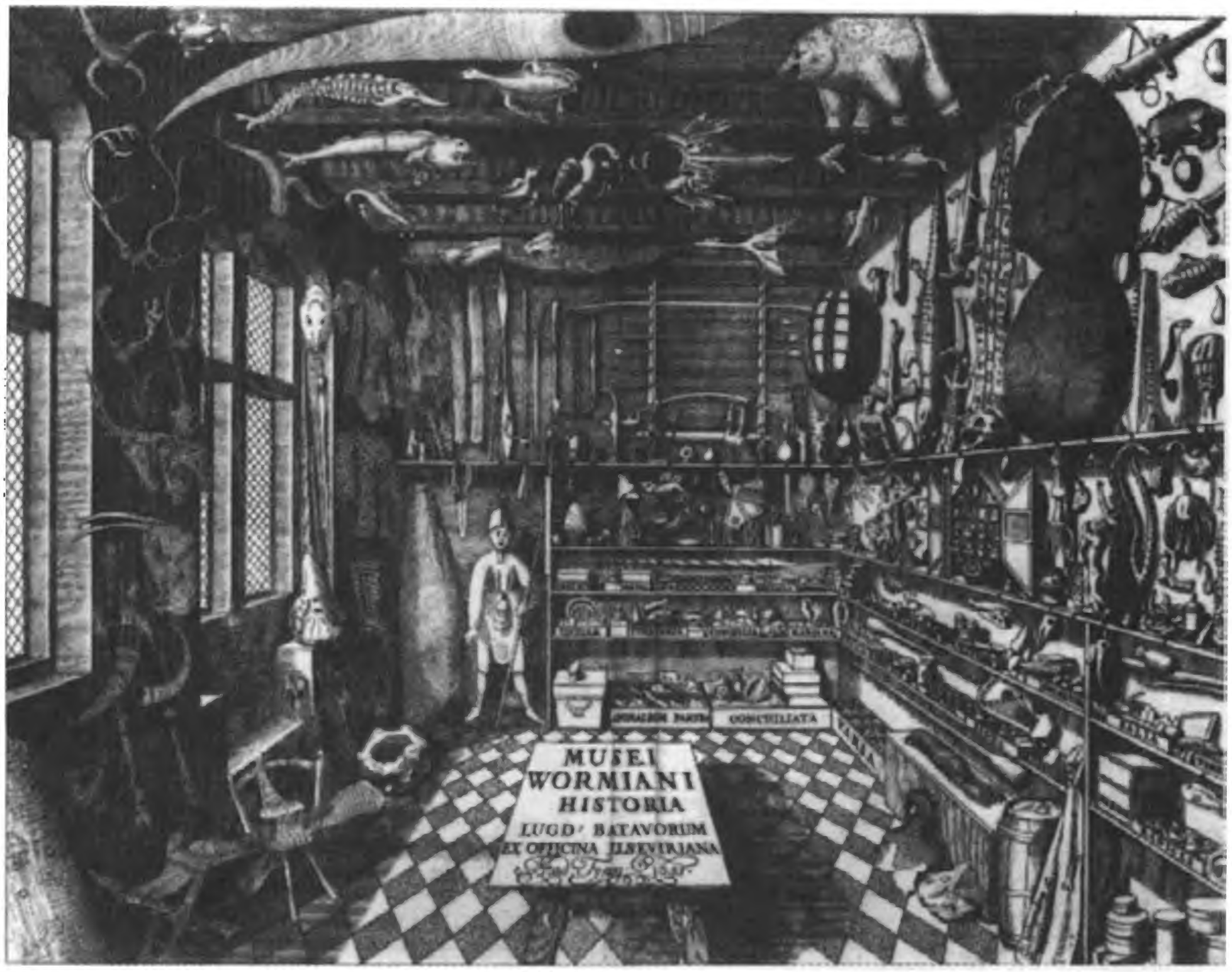

Figure 9.1 Title page from Ole Worm's catalog of his collection of curiousities, mainly *naturalia*, published in 1655. All the specimens are dried. They include human artifacts; stuffed fish, birds, and animals; and skulls, horns, minerals, stones, salts, earths, shells, corals, seeds, leaves, and roots. Courtesy of Wellcome Library, London.

placards; portraits and paintings, large and small; surgical and anatomical instruments; a large Egyptian mummy, windings of Egyptian linen, Chinese paper, and paintings of exotic fruits, nuts, woods, stones, and so on; and other odds and ends. There was also the liver of a young woman of seventeen anatomized by Otto Heurnius in 1620, and the vital organs of pigs. While it is possible that these items were pickled or kept in brine (neither of which preserves the structures for close later inspection), they, too, were more likely dried.[8] So it goes with other collections of *naturalia*: they were based on dried specimens. The result was that collectors could see the shape of things, their forms, but with few exceptions, not their inner structures.

Physicians and pharmacists had long investigated methods for the preservation of small quantities of valuable biologicals. Apothecaries had helped to foster the majolica pottery industry and perhaps helped to stimulate the early modern glass industry as well, since both kinds of containers helped enormously in preserving medicaments by keeping out light, moisture, and air. Apothecaries and physicians were also among the first to pioneer the use of chemical processes for the preparation of medicines; in addition to other

advantages, chemical preparations were not as subject to decay as their biological counterparts. In the sixteenth century, a new technique for preserving botanical material became indispensable for the study of herbal medicines and botany: the first professor of simples at Bologna and first director of the botanical garden at Pisa in the 1530s and 1540s, Luca Ghini, developed a method of taking plants or parts of them and pressing them firmly between sheets of paper while they dried, which preserved their form (and temporarily their color) for later study.[9] These herbaria gave tremendous aid to botanical study, although there remained no substitute for studying living plants in gardens, which consumed huge investments of time and money in the period. Not all plants could be studied in European gardens, however, since many exotics, from tropical climates in particular, died within a season or two. Not until techniques came along like the building of glass houses coupled with special furnaces in the mid to later seventeenth century—a subject handled so well recently by Chandra Mukerji—could the inner structures of many plants be studied.

The study of animals and their parts was even more difficult. Anatomies had to be carried out with some rapidity, especially when working with soft tissue, because of the rapid onset of putrefaction; this is one reason that public anatomies tended to take place in the cold winter months, despite the darkness of the season. Animal parts could be studied at leisure only if dried (as with skeletons) or tanned, neither of which allowed for the investigation of the structures of the body.

Methods to counteract the natural senescence that came with time had been long sought, however. Roger Bacon, for instance, argued that "men used to know what to do about premature physical deterioration: 'per experientias secretas' it had been discovered and written that this rapid aging is accidental (having avoidable side-effects) and therefore can be treated. The medical art cannot achieve this but the experimental art can."[10] His works on the subject were translated into English in 1683.[11] Many other philosophers and alchemists—to say nothing of Ponce de Leon and the search for the fountain of youth—hoped to discover means to prolong human life to at least the age of the biblical patriarchs. Sir Francis Bacon believed that the classical third part of medicine (after preserving health and curing disease), the prolongation of life, would be much improved by his reform of natural philosophy.[12] René Descartes, too, believed that one of the most important results of his own intellectual reforms would be the prolongation of life.[13] Similarly, finding better means to prevent decay and putrefaction also became subject to study. By the middle of the seventeenth century, the rapid growth of new methods of forestalling time's natural processes can be discerned. Although it was a goal which today seems more modest than the prolongation of life, this seems so only in retrospect, probably because solu-

tions to problems of decay began to be found whereas medicines to prolong life remained the stuff of legend. We may think the development of methods for preserving biological specimens worthy of little remark only because we take them for granted. But in ordinary experience, decay and aging appear to be closely related. In the seventeenth century, then, methods to preserve the bodies of living things seemed almost miraculous. They also made the transition from "dry" to "wet" collections possible. The resultant spin-offs for the investigation of nature had important implications.

PRESERVING A LIFELIKE BODY

At first blush, the motivations for trying to preserve animal bodies in a natural-like state seem obvious. As Herman Boerhaave explained in his account of Jan Swammerdam:

> Having gone through his courses [in medicine] with the most sudden and unexpected success, he immediately began to consider how the parts of the body prepared by dissection, could be preserved and kept in constant order and readiness for anatomical demonstrations; as such a discovery would free him not only from the trouble of repeated dissections, but likewise from the difficulty of obtaining fresh subjects, and the disagreeable necessity of inspecting such as were already putrefied.[14]

The details of how Swammerdam and others came to develop methods for preserving whole bodies and body parts is somewhat more complicated, however.

University-educated physicians and surgeons like Swammerdam were preceded and stimulated by the work of Louis de Bils, lord of Coppensdamme and Bonem (both modest fiefs in Flanders).[15] According to the report of Samuel Sorbière, De Bils (b. about 1624) had begun dissecting at the age of thirteen when living in Rouen, and afterward in Flanders and Rotterdam. Why he developed his interest and how he obtained bodies to dissect are both unknown. His father and brothers were merchants, and he himself seems not to have had the kind of good classical education expected of *savants*. Yet by 1646–47, De Bils had a family and was in Amsterdam, where he met the anatomist and surgeon Paul Barbette and the physician-chemist and anatomist François dele Boë Sylvius; a few years thereafter he had taken up residence in Sluis, in Dutch Zeeland not far from Middelburg, a flourishing port city. He continued his anatomical studies and in 1651 gave the University of Leiden a number of preparations made at great expense, acknowledged in a written testimonial by the new professor of anatomy,

Joannes Van Horne. It contained a particularly remarkable specimen: "Above all else is a dried human cadaver that appears to be freshly dead, the most worthy work for such a theater" of anatomy, Van Horne attested.[16] Shortly thereafter Van Horne saw in The Hague another body "balsamed" by De Bils, in which the sinews and plump muscles were displayed as if alive. Apparently working alone, De Bils had found means to prepare human bodies so that they appeared to be full of life rather than dessicated. His secret process of "balsaming" was a fantastic new art in both senses of the word.

De Bils's method was apparently stimulated by the example of Egyptian mummies. Mummies were common objects in the curiosity cabinets of the late sixteenth and early seventeenth centuries, and the period also saw the flourishing of speculation about the wisdom of the Egyptians.[17] Because the brain and viscera were extracted and the remaining skin and muscle were hardened by the preservative process,[18] Egyptian mummies had little to offer the anatomist. But they had long held people fascinated by the length of time they lasted without decay. In an age before modern methods of embalming, they were true wonders. Most European churches and graveyards were places where bodies were buried and decayed, the grounds being continually redug for the burial of additional bodies; sometimes the bones that were recovered in the process were collected in heaps under eves around the outer walls—the charnel houses. Shakespeare's famous "alas poor Yorick" soliloquy is located in such a graveyard, contemplating the skull of a past acquaintance. While the wealthy and powerful might have a stone tablet or other enduring memorial erected in their memory, it was the sign of a miracle to possess a body that did not rot after death.[19] De Bils himself was involved in an investigation of the bodily remains of Maria Margaretha van Valckenisse, mother of a cloister in Oirschot who died in 1658 yet did not decay but rather gave off a sweet oil, declaring the causes to be natural and fraudulent rather than miraculous.[20] Mummies were therefore quite unusual for lasting so long after death.

The power of overcoming putrefaction also made mummies and pieces of them, or more often the powder from pieces of them (both called *mumia*), a sovereign remedy in all kinds of complaints. Karl Dannenfeldt has given us an excellent account of the early modern debate over mumia. He explains the historical process as one by which the use of bituminous products in medicine was transferred to embalmed or desiccated bodies. The precious seepage of black rock-asphalt or pissasphalt from a mountain in Persia, locally called "mumiya," became particularly well regarded. By the thirteenth century, the resinous, aromatic substance exuded from bodies found in Egyptian tombs was considered to be a very similar product. Since asphalt was said to be used by the Egyptians for embalming their dead, the true

mumia could be found in the cavities of the head and body in the "mummies." It was a short step to considering the embalmed flesh—and even the wrappings—to contain the precious resin.[21] Antonius [Musa] Brasavola's *Examen omnium simplicium medicamentorum* (1537), defined "*mumia* as the remains of an enbalmed body and the same as bitumen judiacum."[22] The textbook on chemistry by Joachim Tanckius, professor at Leipzig, simply stated that "*Mumia* is the arcanum and secret of the microcosm."[23] Consequently, European demand for mummies became so high that the Egyptian government was forced to outlaw the export of mummies, although a large contraband trade in both true and counterfeited mummies continued through the early modern period.[24]

Medical practitioners also attempted to make mumia themselves. Paracelsus and his followers, for instance, described mumia as a force in living tissue that attacked invading disease semina. Andreas Tentzel's *Medicina diastatica* (1629) "was primarily devoted to mumia, of which he enlarged the scope and definition. Now there was extraction of the mumia of the aerial body by interception of the dying breath."[25] More practically, however, flesh from those who died healthy and without disease—especially those who died a violent death—was thought by Paracelsus and his followers to still radiate the power of mumia, so that the flesh of the recently deceased could be used after exposing it to the air for a day and a night. Oswald Croll was even more precise: the best tincture of mumia was prepared from the flesh of a "red-haired man twenty-four years old, who had been hanged, broken on the wheel, or thrust-through, exposed to the air for a day and a night, then cut into small pieces or slices, sprinkled with a little powder of myrrh and aloes, soaked in spirits of wine, dried, soaked again, and dried." From this could be extracted a red tincture, "a quintessence, which could be used for cures of pestilence, venin, and pleurisy."[26] (Perhaps the trade in mumia affected the debate about cannibalism in early modern Europe).[27] It is no surprise, then, to find Dutch physicians setting recipes for making mumia alongside receipts for embalming bodies.[28]

As for the process by which the Egyptians mummified their dead, the main ingredients were thought to be myrrh and aloes, as well as other resins. It is probably needless to remind anyone that in the Christmas story Magi bear gifts of myrrh and frankincense, two resins from "Arabia" (as Europeans knew the Near and Middle East) very valuable in medicine; closely related to the resins, according to Dioscorides, were the substances in the category pitch, including asphalt and other substances related to the original "mumiya." As one commentator explained: in order to thwart the usual course of putrefaction, the Egyptians disemboweled the dead and repeatedly steeped them in bitumen and stuffed them with precious aromatics.[29] Aromatic and oily resins were also those things that often went under the rubric

of "balsam," or in English, "balm." It is clear that De Bils was experimenting with various expensive oils and resins such as myrrh when he engaged in "balsaming" (*balsemen* remains the Dutch verb for the English "embalming"). Given the high prices of the imported balms, his experimental costs must indeed have been enormous.

What De Bils was trying to do went further than what the Egyptians had done, however. For mummification preserved only the external form of the body. While the body endured permanently and could be examined without any effusion of blood or fluids that might offend those with delicate sensibilities, mummies were useless for the anatomist. The bodies were hardened and the viscera absent.[30] De Bils, however, was developing methods of preserving the whole body in a lifelike manner.

De Bils's personal affairs suffered badly in the early 1650s, but he kept up his investigations. After the death of his father, he and his brothers, merchants in Rouen, became embroiled in various lawsuits against one another about the inheritance. Although he obtained the office of bailiff of Aardenburg, the pay was slight, and he seems not to have invested much energy in the position.[31] But two medical friends in Sluis, Drs. Abraham Parent and Laurens Jordaen, both of whom had studied at Padua, helped De Bils with his anatomical work and jointly published a pamphlet on De Bils's investigations on the anatomy of the inner ear. They both moved away in the mid-1650s, however, lessening De Bils's opportunities for anatomical study.[32] By 1657, De Bils was searching for new means of support. A physician in Brugges (not far from Sluis), Burchardus Wittenberg, wrote a tract highly praising De Bils's achievements and calling on a prince to support him, so that his work was not paid for out of his own pocket. Through an intermediary De Bils tried to interest professor Van Horne in working with him, but Van Horne seems to have balked at the probable expense. De Bils did finally get the financial support of a physician from Middelburg for his research and publication on the lymphatics. But this publication hit a nerve with Van Horne, who expressed complete surprise at De Bils's work. Van Horne quickly turned out a Latin translation of the book, although criticizing it at the same time.[33] According to the historian G. A. Lindeboom, Van Horne himself "now applied himself to the making of fine anatomical preparations"[34]—a matter to which we will return in a moment.

Given De Bils's successes, the States General of the Dutch Republic issued an order on 9 August 1658 for the public provision of bodies to De Bils, while new translations into Dutch of anatomical works by Thomas Bartholinus and Paul Barbette allowed De Bils to study further. His friend Parent also published a notice again urging support for De Bils's work, which was so costly—especially the balsams. The city of Rotterdam, to which De Bils had followed Parent, set up an anatomical theater over the

former English merchants' courthouse. De Bils used it for further studies on his secret method of dissecting and balsaming, and for the display of at least four dissected and balsamed cadavers. Apparently a "sovereign power" sought to get him to sell his secret several times, but he refused in favor of setting up his show in Rotterdam, for which he charged an admission of 1 rijksdaalder. Despite the high entry fee, his display was heavily attended by physicians and students as well as the public, from ordinary people to ambassadors and princes. He also held public anatomical demonstrations. His special technique was to dissect without losing any blood or other moisture from the body. For such theatrical presentations he charged even more.[35]

But after initial support, encouraging students and others to attend De Bils's displays and demonstrations, Van Horne turned against De Bils in writing. He had become proud, telling the world that students learned more from him in half an hour than from Van Horne in two years. Van Horne in turn decided that De Bils was a pretender, with neither learning nor gentlemanly behavior. The Amsterdam surgeon Barbette also turned against De Bils. He, too, underlined the absence of academic education in De Bils: "Philosophy, chemistry, astronomy, medicine, and daily practice" were absolutely necessary for understanding the workings of the body, but for two years the unlettered De Bils had pretended to be the great master overturning all established learning. De Bils replied to these two sallies with his own pamphlet of March 1660, in which he ascribed Van Horne's and Barbette's criticisms to jealousy. But in attacking them he also further attacked, and further alienated, learned physicians generally. The debate continued throughout De Bils's life (he died in 1669)—he had some supporters in the Dutch Republic as well as antagonists. But the one matter that continued to be praised even by his strongest opponents was his balsaming of cadavers.[36]

De Bils promised to reveal the secret of his process for 120,000 guilders. But he was willing to part with two balsamed cadavers to one Duke Christiaan for 16,000 guilders. At the end of 1661, it was rumored that he had sold his secret to a nobleman. This may well have been prompted by the attempts of Luis de Benavides Carillo y Tolede, marquess de Caracena, a follower of Don Jan van Oostenrijk, stadtholder of the southern Netherlands, to purchase De Bils's collections for the University of Louvain. After inspection of some of De Bils's cadavers in November 1662, Gerard van Gutschoven, a professor of medicine there, became quite enthusiastic about the possibility of obtaining De Bils's specimens. Oostenrijk proposed to the states of Brabant that they purchase De Bils's cadavers and his secret method. By June 1663, eighteen articles had been drawn up by which De Bils agreed to provide Louvain with five cadavers and all his knowledge, including his secret embalming process. The process, and his method of bloodless dissection, would be written in duplicate in Latin, with a Dutch version for De Bils; the

two Latin copies would be deposited in separate places, in strongboxes sealed by two keys, one key to be held by the states of Brabant and the other by the professors of Louvain. Various other provisions ensured that De Bils swore that he had not and would not reveal the secret to anyone else. In return, the states promised a payment of 22,000 Rhenish guilders, and a professorship salaried at 2,000 guilders per year, which would revert to his son after his death. De Bils would also establish an anatomy theater in Louvain without charging for admission. By October some changes were made to this draft contract, and Van Gutschoven began to learn De Bils's secret under his tutelage. At the same time, as word of the arrangement got out, people began to insist in their wills that their bodies be embalmed by De Bils's method.[37]

Finally, on 16 April 1664 De Bils's secret was handed over in writing and shown to Van Gutschoven, who was allowed eleven minutes in private to read it, after which he stated that he understood the methods of bloodless dissection and balsaming of bodies. By May, the five bodies De Bils owed the Louvain faculty were in hand, and the states paid out the 22,000 guilders. There was as yet no place prepared for the cadavers, and so they were placed in the basement of the library; after four hot months, they were laid out on tables under a roof with holes in it, subject to rain and snow, which not only damaged books in the library but caused some signs of rot to appear in three of the five cadavers by 1666. This later became known to De Bils's opponents, who claimed it proved him a fraud. But despite these and financial difficulties, De Bils remained well regarded in Louvain and the southern Netherlands: in early 1669 Flanders awarded him the benefice of a canon of 's Hertogenbosch and St. Oedenrode, and made him an honorary professor of anatomy at the Illustrious School. During that same year, several public demonstrations of his method were to be undertaken in the northern Netherlands with the assistance of Tobias Andreae—but De Bils sickened and died. Andreae lent his help to trying to sell De Bils's secret in Amsterdam, coming into difficulties with the Leiden-educated physician and surgeon Frederick Ruysch in doing so.[38]

The process De Bils had developed and written down in 1664 was as follows: A tin box [*tinne kiste*] 8 feet long by 2 1/2 feet wide by 3 feet high was placed in a wooden box trimmed and caulked so as to let in no light and fixed with iron bands; into the lid of the wooden box was cut a trap door [*schuyve*] that could be opened and completely sealed. The tin box would also be covered at the appropriate time with double wool blankets so that no light could enter. Into the tin box was introduced 60 pints of the very best rum, freshly made; 50 pints of Roman alum very finely ground; 50 pints of pepper very finely ground; 1 sack of salt finely ground, which must be poured in at this point; 200 large glasses [*stoop*] of the very best brandy of Nantes; 100 large glasses of the very best wine vinegar, all of which were

well mixed in the tin box as quickly as possible so as not to let the power of the mixture get lost [*opdat de kracht niet te veel en verlighe van ditto substantie*]. Twenty pounds of finely ground myrrh of the best kind and 20 pounds of the best finely ground aloes [*allouwe*] could also be added to the mixture. The dead body, wound about with a white linen sheet, was immediately dunked in this mixture, lying on and tied to a wooden platform [*stellinghe*] so that at least two feet of fluid covered it. The boxes were closed for thirty days, except that three days after the body was put in the fluid, the mixture was well stirred, as it was twice more during the thirty-day period. Each time the fluid was stirred, the body was also taken out, unwrapped, washed in fresh brandy, flipped over so as to drain out any moisture via the mouth (being careful not to damage the hair or finger- and toenails), rewrapped in sheets, and replaced. After the thirty days, the body was transferred to another box made like the first with a mixture of rum, pepper, alum, salt, brandy, and vinegar in the previous proportions, in which it was left for sixty days (with three stirrings and turnings). The above mixtures were for kings or others whose bodies were to be displayed in public. If this was not to be the case, the rum and alum could be left out of the first mixture and the spices had to be added, and in the second mixture no salt was added, nor rum and alum. Between the second and third soaking, the body was allowed to dry. The first box was in the meantime cleaned and filled with a third mixture, which excluded the rum, alum, and salt but included the myrrh and aloes; this mixture was stirred several times and the clear liquid that came to the surface was skimmed off. Then 44 pounds of aloes, 44 pounds of myrrh, 20 pounds of *foullie*, 20 pounds of cloves, 20 pounds of cinnamon, 20 pounds of nutmeg (all of the best kind, finely ground), 1/4 pound of ambergris, 1/4 pound of black balsam, with a 1/2 pound of oil of cinnamon were all mixed together and applied several times to the exterior of the body and allowed to dry. The body must lie in the third mixture for two months, being turned over periodically as before, being washed and rinsed with the clear liquid skimmed off previously. If after all this the body fat had not completely dried up, the body would be placed in a small, tight stone room with two ovens burning low, one of which burned 2 pounds of mastix. After the body was thoroughly dried, the ambergris mixture was applied to the body again. The specimen could be best kept in a tin box that let in no air.[39]

UNFORESEEN CONSEQUENCES: THE STRUCTURES OF THE BODY

Because De Bils had kept his method secret, however, others had to guess at the means and experiment with possibilities themselves. In March 1661 it was rumored that a Dr. Hubertus of Leiden had discovered some of De

Bils's secrets, and later in the year a story was circulating that De Bils had sold his secret to a nobleman who passed it on to one Burrhus in Leiden—although nothing more is known.[40] A student at Leiden at the time, Theodorus Kerckring, "is said to have invented," a means of "preserving dead bodies by covering them with varnish."[41] In another version, he "performed experiments with liquefied amber to preserve corpses."[42] Another contemporary, Gabriel Clauder, thought that De Bils was using salts. A medical student at Leipzig (and later physician to the electors of Saxony), Clauder was making a grand tour of Europe and England in 1660 and 1661[43] when he visited De Bils's cabinet. According to his 1679 *Methodus balsamandi corpora humana*, he "applied his moistened finger to one of the bodies, and carrying it to his lips recognized the taste of salts. He started from this fact to attempt numerous researches, and succeeded in forming different compounds." His salt was composed as follows: "Dissolve one pound of common salt with a pound of oil of vitriol [sulfuric acid] in a crucible, apply a cover closely luted, and distill it gradually in a sand bath; you may pour off a spirit very excellent for a lotion; in the bottom of the crucible will remain a *caput mortuum*, which should be dissolved according to art, and after evaporation, you will have the salt so much esteemed by the author."[44]

Better known are the investigations of Jan Swammerdam, who matriculated in medicine at Leiden in 1661 after already having had experience with anatomical work at home in Amsterdam; he quickly became one of the favorite pupils of Van Horne and of François dela Boë Sylvius. In 1652 Van Horne had announced the discovery of the thoracic duct; in the early 1660s, Swammerdam made a durable preparation of it by soaking it in alcohol and then drying it.[45] But the centerpieces of Swammerdam's cabinet were a preserved child of one month, and a whole lamb, both of which he balsamed using a process simpler but similar to De Bils's. According to Justus Schrader—a slightly younger student of Van Horne's—Swammerdam's technique of balsaming was as follows: First, a tin vessel large enough to receive the corpse was prepared. Into this was set a grate or screen resting two fingers' width above the bottom, on which the body was placed. Then oil of turpentine was poured in to a height of three fingers' breadth from the bottom. The vessel was covered tightly except for a tiny opening, and set aside for time to do its work. This most penetrating oil entered the pores and replaced the fluids that caused fermentation and decay, which due to their weight descended through the screen to the bottom of the vessel while at the same time the volatile oils evaporated through the small opening in the top, leaving the specimen coated throughout with the hardened oil, which prevented it from decay.[46] Different organs required longer or lesser times: an embryo took six months, a skeleton about two, the parenchymia of the heart three, a liver and a placenta one, a spleen ten days, and intestines a month.[47]

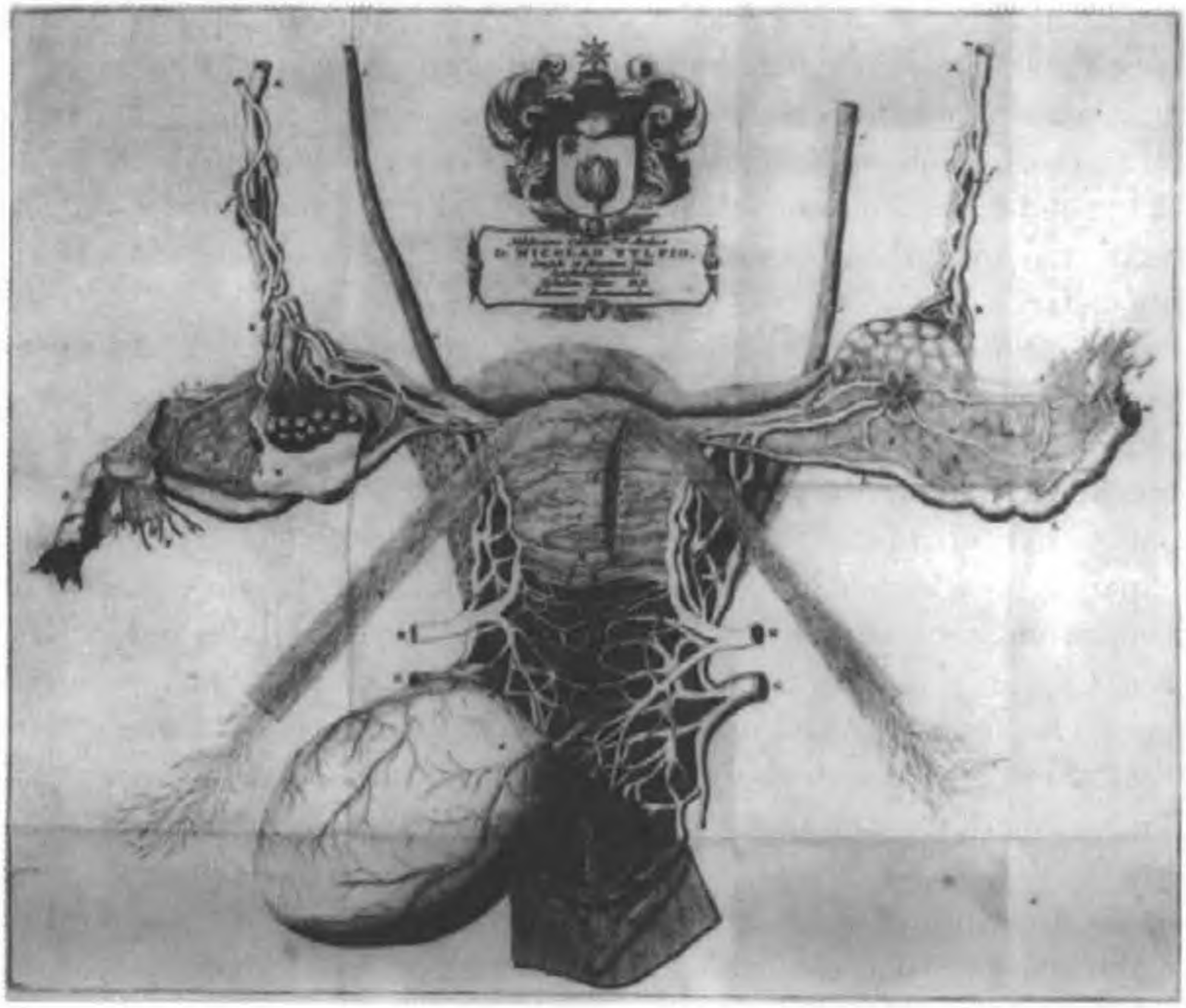

Figure 9.2 Engraving of a preserved female human uterus as depicted by Jan Swammerdam, from his *Miraculum Naturae Sive Uteri Muliebris Fabrica* (1672). The structures of these soft tissues were discovered using preservatives and injections of various kinds. Courtesy of the Universiteit Bibliotheek Leiden.

A few other techniques helped prepare more complicated specimens. With bodies and organs properly prepared, one could also inflate the vessels with air, wax, mercury, and other substances. Using such techniques, Swammerdam was able to examine the structure of the lung, the follicles of the human uterus, the ramifications of the vessels of the placenta, and so on[48] (fig. 9.2).

With a few elaborations, the method developed by Swammerdam continued to be taught at the University of Leiden. For instance, Carel Maets (or De Maets, Dematius), who had been teaching experimental chemistry at Leiden since 1669, explained his private method of preserving bodies from at least 1674.[49] He elaborated the method in his *Chemia rationalis* of 1687: "After first removing the intestines, viscera, brain, and all other soft parts, it is then placed in a lead coffin [*cysta*] commodious enough for it, where it is soaked in clear oil of turpentine. After fourteen days, or when the oil has well penetrated all the parts of the muscles, remove it and wash it with spir-

its of wine, and put it in a place where it will dry." To preserve the soft tissues, they were first inflated and injected with lukewarm water so as to evacuate all the blood; then they were washed out with spirit of wine until no trace of blood remained, after which they were dried in appropriate shape and soaked in oil of turpentine.[50] Another former Leiden student, Stephen Blankaart, also wrote about the use of oil of turpentine for balsaming bodies.[51]

Thus, the key ingredient for the Leiden experimenters was oil of turpentine. The turpentine commonly in use at the present day, a product of fir and pine trees, has little relation to the substance called turpentine or terebinth, much less its oil, in the seventeenth century. At that time the word applied only to an exudation of the terebinth tree (now called *Pistacia terebinthus*, or Chian turpentine). As John Goodyer explained in his 1655 edition of Dioscorides, the tree grew in "Arabia Petraea" as well as "Judea and in Syria & in Cyprus, & in Africa, & in the Islands called Cyclades." He also noted that "The Resina Terebinthina doth surpass all other rosins."[52] Twenty years later, the English military surgeon James Yonge warned that "there is a base Turpentine-like substance called commonly Terebinth, brought from France, drawn from the Fir and other Trees, . . . which is no more the gum of the Turpentine tree, than Tar is."[53] This is confirmed by the reports of major sixteenth-century investigators: "Champier said larch-tree resin was sold for terebinth but Brasavola reported in the mid-sixteenth century true terebinth was now imported in round lumps from Cyprus to Venice."[54] The oil of true turpentine, as Yonge explained, itself "contain[s] in it the Balsam."[55] Moreover, one definition of balsam itself was "an aromatic oily or resinous medicinal preparation . . . specifically, of various substances dissolved in oil of turpentine."[56] The oil or "spirit" of turpentine ("they being names promiscuously given to one and the same kinds of thing") was obtained after a slow distillation of the resin of the terebinth tree in a retort, which produced first a white, then a yellow, and finally a red oil, the last of which was the best.[57] When the red oil was mixed with blood, Yonge explained, curious things happened, among which was a coagulation that made it a very useful styptic for stanching wounds. For chemists of the day, experiments with oil of turpentine were common. One of the experiments most often repeated by Robert Boyle was the action of oil of vitriol distilled in a retort with turpentine, which yielded sulfur.[58]

Perhaps it is even significant that "oil of turpentine was regarded as very similar to spirit of wine,"[59] for in England, sometime in the 1650s, apparently at the suggestion of William Croon, Robert Boyle discovered that the spirit—or oil—of wine (something resembling today's brandy) could be used to preserve anatomical specimens. He had been so excited by news of De Bils's invention that he published a translation of one of De Bils's pam-

Figure 9.8 A prepared child's arm holding *naturalia*, clothed in a sleeve with lace (specimen prepared by Rachel Ruysch, Frederik's daughter). From Ruysch, *Opera omnia*. Courtesy of Metamedica, Rijksuniversiteit Leiden.

phlets. In 1663 his specimens of "a linnet and a little snake, preserved already four months, entrails and all, without any change in colour, in some spirit of wine," were to be found in the Royal Society's repository.[60] Whether such trials were stimulated by news of the efforts of De Bils and others is unknown. Although the results were slightly imperfect, and the liquid had to be periodically refreshed, the simplicity of suspending specimens in spirit of wine in a glass container made it a very important discovery. As one can tell from some of the methods used by the Dutch, spirit of wine was also used together with oil of turpentine to produce preserved specimens that could be handled.

The use of oil of turpentine and other materials for the preservation of anatomical specimens was rich in unintended consequences, however. For instance, Swammerdam was the first to see the anatomy of insects as something other than an almost undifferentiated jelly. He could do so because of his technique using very fine scissors and tweezers, excellent microscopic technique, mounting platforms of his own design, and oil of turpentine. The latter preserved the bodies of insects that could not be dried, but more: oil of turpentine turned the body fats of insects into a kind of lime, which could be carefully washed away, leaving their fibrous tissue exposed to the eye.[61] When the young Cosimo de' Medici visited his cabinet in 1668, therefore, Swammerdam famously dissected a caterpillar to show how the wings of the future butterfly were already contained in the body of the caterpillar. The demonstration held great importance in showing that metamorphosis was not an alchemical transformation of one kind of matter into another, but rather an unfolding of parts already present. The grand duke was so impressed with the skill and novelty of Swammerdam's work that he offered him 12,000 guilders for his collection of insects—an enormous sum—if he would bring it to Florence and enter his service, an offer Swammerdam declined.[62]

Methods for preserving bodies also allowed for the development of other techniques of anatomical investigation. For instance, working with Van Horne on 21 January 1667 on a human uterus (preserved with oil of turpentine, as Schrader noted above) Swammerdam found means to inject the uterus with wax—a technique he further developed, together with injections of air—filling out vessels that could not otherwise be discerned.[63] His cabinet contained a preparation of the lungs in which the trachea was filled with white wax even to tiniest parts, the pulmonary artery was filled with red wax, the pulmonary vein with rose wax, and the small orifices of the arteria bronchialis with a fire-red substance; he showed a liver similarly differentiated in balsam and wax.[64] He was able to show that the human spinal marrow was composed of fibrous nerves by suddenly placing the yet warm spinal vertebrae in cold water, leaving them there for twenty-four hours,

and then carefully breaking off the bone to expose the marrow—which again had turned from an undifferentiated mass into tissues.[65] What had begun as an attempt to defy time by preserving bodies from the process of decay had also become an experimental technique crucial to the development of new anatomical knowledge.

Frederik Ruysch developed the Leiden methods to a high pitch. A fellow student of Swammerdam's, Ruysch became perhaps the most innovative anatomist of the late seventeenth century. His cabinet was an extraordinary sight, full of embalmed and preserved specimens in lifelike poses and dress, and strange fish and organs in bottles. The centerpieces of his displays were his thesaurii: dioramas of tiny human skeletons in poses memorializing the fleeting world of time by (for instance) playing violins made from hardened body parts, all standing among woods made from hardened arteries and veins, and rocks made from bladder stones (fig. 9.4). At the same time that they drew the viewer's attention to the instabilities of time, the specimens themselves represented permanence in the face of the forces of decay. When Tsar Peter visited Ruysch's cabinet, there in a cradle lay an embalmed baby with glass eyes that looked so lifelike and peaceful that he bent down to kiss the child. In 1717, the tsar purchased this emblem of the new science, along with the rest of the specimens in the cabinet, for 30,000 guilders; parts of the collection remain in St. Petersburg. (Ruysch had sold his collections before, laboriously building up new ones.)[66]

CONCLUSIONS

By the mid-seventeenth century, the process of secularization—of investigating the world of time by altering time's previously unalterable movement—was well under way, in the world of science as well as commerce. Perhaps it is not surprising that the most notable investigators had powerful ties to the world of business: De Bils came from a merchant family, Swammerdam from a family of apothecaries located next to the VOC warehouses in Amsterdam, Ruysch from civil servants so down on their luck that he became apprenticed to a pharmacist. Probably all lost more money than they made from their investigations. They turned their material inheritances into wonders of nature. Yet in distorting the "natural" actions of time as they did, De Bils, Swammerdam, and Ruysch also "capitalized" on their work by turning it into money, or could have.

For naturalists, like merchants, the accumulation and preservation of things was in anticipation of later demand. For the sake of future generations as well as immediate curiosity, they undertook the investment in intellectual capital: in specimens and an inventory of details about them (fig 9.5).

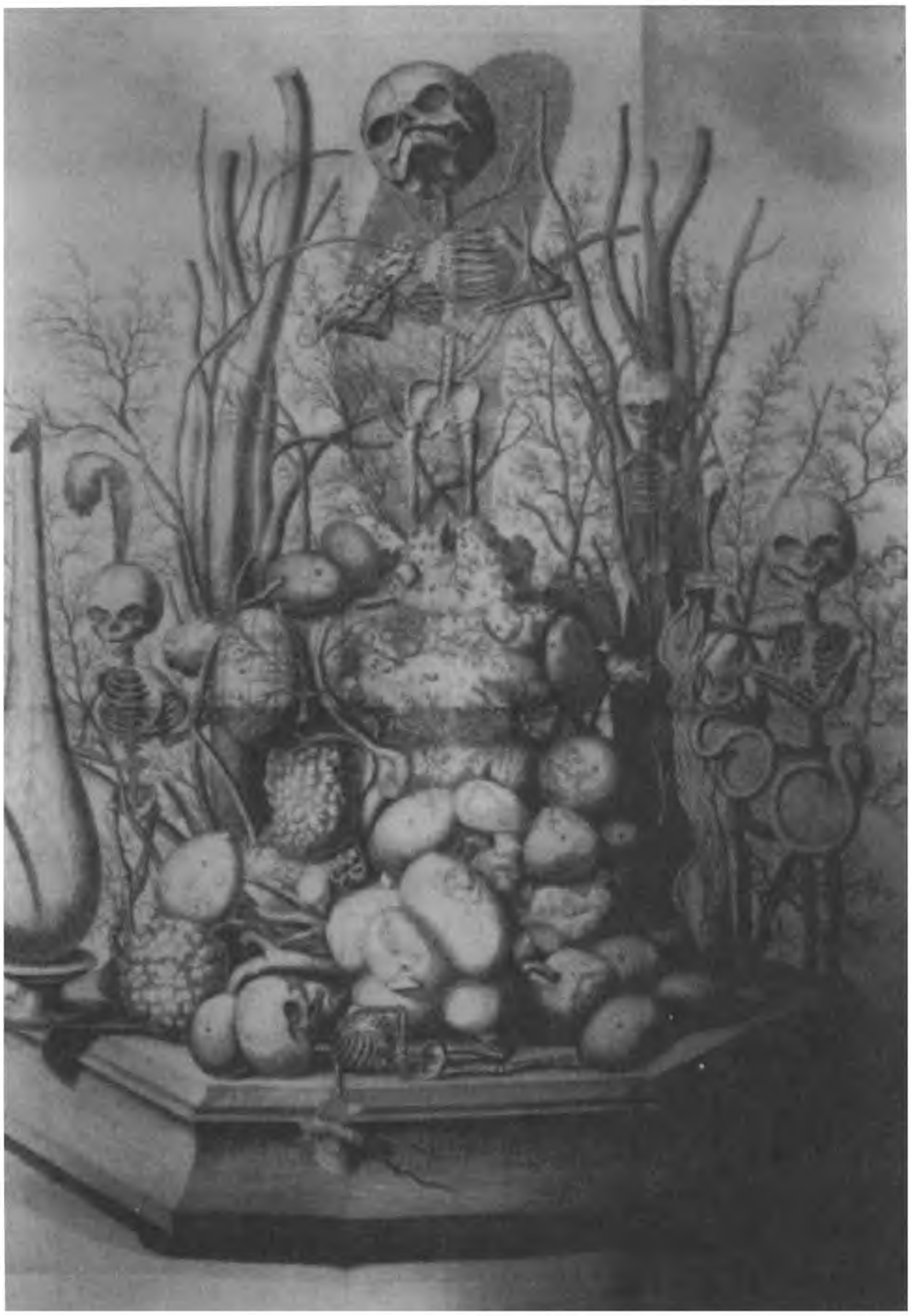

Figure 9.4 One of Ruysch's thesaurii (the third) depicting the shortness of life, constructed from kidney, gall, and bladder stones, trees made from dried veins and arteries, topped with fetal skeletons in various poses: a central figure looks heavenward, singing a lament ("Ah fate, bitter fate!") while accompanying itself on the violin; a small figure to its immediate right conducts the music with a baton set with minute kidney stones; on the far right is a skeleton girded with sheep intestines injected with wax, a spear made from a hardened male vas deferens conveying a message about man's first hour also being his last; to the left is a figure with a feather, a symbol of vanitas; and in front is a tiny skeleton holding in its hand a mayfly—an insect on which Swammerdam had written a famous book, centering his moral argument on the supposed fact that the creature lived in its adult form for only one day. From Ruysch's *Opera omni anatomico-medico-chirurgi* (1721–1727). Courtesy of Middleton Health Sciences Library, University of Wisconsin, Madison.

Figure 9.5 The cabinet of Bernard Sigfried Albinus, who carried on the tradition of anatomical preparation and study at Leiden, illustrating how a professor's cabinet had become replete with wet specimens by the 1740s. Courtesy of Metamedica, Rijksuniversiteit Leiden.

Material progress and utility became the watchwords of contemporary naturalists even when reveling in curiosities. They wished to create enduring knowledge from fragile and perishable objects by thorough-going investigation and reporting, which could be handed down to others. But they, too, as much as merchants, depended on preserving their accumulated objects. Just as a warehouse of nutmeg would lose much or even most of its value should mold take over (hence the dusting of it with lime), so a cabinet of curiosity lost value as its specimens were lost or destroyed. Investing for the long term might add value to one's transactions, but it also required a struggle against the processes of decay and putrefaction. New methods of both capitalism and science therefore depended on working against the forces of transitory nature in favor of longer term durability. Given an outlook that valued not only material bodies themselves but the accumulation and preservation of them, coupled with methods of investigation linked to thinking about how to get value from time, ingenious people like De Bils and Swammerdam added to the store of knowledge, now part of our intellectual capital.

1. David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (Cambridge, Mass.: Harvard University Press, Belknap, 1983), 72–76.

2. On musical horology, see Penelope Gouk, *Music, Science, and Natural Magic on Seventeenth-Century England* (New Haven, Conn.: Yale University Press, 1999), 202–204.

3. Norbert Elias, *Time: An Essay*, trans. by Edmund Jephcott, reprint, 1987 (Oxford: Blackwell, 1992), 115. Elias emphasizes the phenomenological approach to understanding time. For one who argues for the absolute existence of space and time, in which space-time points "stand in causal relations to one another," see Michael Tooley, *Time, Tense, and Causation* (Oxford: Clarendon Press, 1997), quotation on 379. For a collection of essays informed by modern physical science, see Steven F. Savitt, ed., *Time's Arrows Today: Recent Physical and Philosophical Work on the Direction of Time* (Cambridge: Cambridge University Press, 1995).

4. Jan de Vries and Ad van der Woude, *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500–1815* (Cambridge: Cambridge University Press, 1997), 691, 692.

5. Niels Steensgaard, *The Asian Trade Revolution of the Seventeenth Century: The East India Companies and the Decline of the Caravan Trade* (Chicago: University of Chicago Press, 1974), 142–143, 149.

6. P. W. Klein and J. W. Veluwenkamp, "The Role of the Entrepreneur in the Economic Expansion of the Dutch Republic," in *Economic and Social History of the Netherlands*, Het Nederlandsch Economisch-Historisch Archief, Vol. 4 (Amsterdam: NEHA, 1993), 28, 31–32, 33, 49.

7. F. W. T. Hunger, "Bernardus Paludanus (Berent ten Broecke) (1550–1633)," *Janus* 32 (1928): 361.

8. J. A. J. Barge, *De oudste inventaris der oudste academische anatomie in Nederland* (Leiden: H. E. Stenfert Kroese's, 1934), 34–55.

9. Karen Meier Reeds, *Botany in Medieval and Renaissance Universities*, Harvard Dissertations in the History of Science (New York: Garland, 1991), esp. 35–36.

10. Faye Getz, "Roger Bacon and Medicine: The Paradox of the Forbidden Fruit and the Secrets of Long Life," in *Roger Bacon and the Sciences: Commemorative Essays*, ed. Jeremiah Hackett (Leiden: Brill, 1997), 337–364.

11. *The Cure of Old Age, and Preservation of Youth. By Roger Bacon . . . Translated out of Latin; with annotations and an account of his life and writings. By Richard Browne* (London: Tho. Flesher and Edward Evets, 1683).

12. Sir Francis Bacon, "De augmentis scientiarum," translated as "Of the Dignity and Advancement of Learning," in his *Works*, ed. and trans. James Spedding (London, 1860), Vol. 4, book 4, chap. 2, 390–394.

13. See, for example, his letter to Chanu of 15 June 1646; AT IV:441–442.

14. Swammerdam, *The Book of Nature; or, the History of Insects*, trans. Thomas Flloyd, revised with notes by John Hill (London: C. G. Seyffert, 1758), ii; for the original, see Swammerdam, *Bybel der Natuure/Biblia Naturae*, ed. Herman Boerhaave, with facing-page translation into Latin by Hieronimus David Gaubius (Leiden: Isaak Severinus, Boudewyn vander Aa, Pieter vander Aa, 1737), sig. B.

15. For what follows, I am heavily indebted to Jan Reinier Jansma, *Louis de Bils en de anatomie van zijn tijd* (Hoogeveen: C. Pet, 1919).

16. " . . . sed fidem superat omnem, exsiccatum hominis Cadaver Recenter Mortuum Diceres tanto Theatro Dignissimum opus." The wooden plaque containing Van Horne's testimony is reproduced on 47 of Jansma, *De Bils*. De Bils later claimed that he had spent *f* 40,000 on the preparations, not including his time (66).

17. On Egyptian mummies in cabinets, see both examples above. The famous work of Hermes Trismegistus was thought to have been written at the beginning of Egyptian civilization; on the fascination with Egypt, see for example Frances A. Yates, *Giordano Bruno and the Hermetic Tradition*, reprint, 1964 (New York: Vintage Books, 1969); Thomas C. Singer, "Hieroglyphs, Real Characters, and the Idea of Natural Language in English Seventeenth-Century Thought," *Journal of the History of Ideas* 50 (1989): 49–70; Anthony Grafton, *Defenders of the Text: The Traditions of Scholarship in an Age of Science, 1450–1800* (Cambridge, Mass.: Harvard University Press, 1991), 145–177.

18. Alfred Lucas, *Ancient Egyptian Materials and Industries*, 4th ed., revised by J. R. Harris (London: Edward Arnold, 1962), 270–326.

19. See esp. Katharine Park, "The Criminal and the Saintly Body: Autopsy and Dissection in Renaissance Italy," *Renaissance Quarterly* 47 (1994): 1–33; Katharine Park, "The Life of the Corpse: Division and Dissection in Late Medieval Europe," *Journal of the History of Medicine* 50 (1995): 111–132.

20. Jansma, *De Bils*, 70–74.

21. Karl H. Dannenfeldt, "Egyptian Mumia: The Sixteenth-Century Experience and Debate," *Sixteenth-Century Journal* 16 (1985): 163–180.

22. J.R. Partington, *A History of Chemistry,* (London: Macmillan, 1961) 2:98.

23. Lynn Thorndike, *A History of Magic and Experimental Science* (New York: Columbia University Press, 1923–58), 8: 106.

24. Dannenfeldt, "Egyptian Mumia," 169–171.

25. Thorndike, *A History of Magic and Experimental Science*, 8: 414.

26. Dannenfeldt, "Egyptian Mumia," 173–174; Partington, *A History of Chemistry,* 2:444.

27. William Eamon, "Cannibalism and Contagion: Framing Syphilis in Counter-Reformation Italy," *Early Science and Medicine* 3 (1998): 1–31.

28. For example, see Carolus de Maets, *Chemia Rationalis* (Lugd. Batav.: Jacobum Mocquee, 1687), 162–164, and a manuscript of his chemistry course from 1675 and 1676, British Library, Sloane MSS 1235, fols. 5–5b.

29. Justus Schrader, *Observationes et Historiae* (Amsterdam: Abraham Wolfgang, 1674), 236: "Notum est, cadaverum artus ac viscera sibi relicta necessariò ruere in putredinem, eorumque compagem nunc citiùs nunc tardiùs foedâ corruptione dissolvi, nec ullum pristinæ integritatis aut formæ vistigium tandem retinere. Hunc consuetum naturæ cursum arte non solùm refrænari sed & cohiberi posse, dudum evicerunt medicata Ægyptiorum funera bitumine ac pretiosis subinde refinis & aromatibus abundè infarcta."

30. Ibid., 236: "quae tamen quum externam solummodò speciem servent, idque obscurè, non item interiorum habitudinem, meritò isti Ægyptiaco operi præfertur illa ars, quae cadavera & eorum fragmina ita obdurat, ut salva permaneat ipsorum textura, idem supersit color, eadem conformatio, nullo non tempore ac pro lubitu ab Anatomico contemplanda, & quidem absque cruoris effusione, aut fastidioso madore, quibus delicatiores offendi, & ab inspiciendis demortuorum visceribus communiter arceri solent."

31. Jansma, *De Bils*, 48–53.

32. G. A. Lindeboom, *Dutch Medical Biography: A Biographical Dictionary of Dutch Physicians and Surgeons 1475–1975* (Amsterdam: Rodopi, 1984).

33. Jansma, *De Bils*, 53–54.

34. Lindeboom, *Dutch Medical Biography*, col. 909.

35. Jansma, *De Bils*, 54–58.

36. Ibid., 58–67.

37. Ibid., 65, 67, 68–69.

38. Ibid., 77, 78–79, 83–88, 90.

39. Ibid., 96–99.

40. Ibid., 67.

41. Partington, *A History of Chemistry*, 2:208.

42. Lindeboom, *Dutch Medical Biography*, 1031.

43. N. F. J. Eloy, *Dictionnaire historique de la médecine ancienne et moderne: Ou mémoires disposés en ordre alphabétique pour servir a l'histoire de cette science* (Mons: H. Hoyois, 1778), 655–656.

44. Jean Nicolas Gannal and R. Harlan, trans. and eds., *History of Embalming, and of Preparations in Anatomy, Pathology, and Natural History; Including an Account of a New Process for Embalming* (Philadelphia: Judah Dobson, 1840), 91–92, 96; see Gabriel Clauder, *Methodus Balsamandi Corpora Humana* (Iena: Oan Bielckium, 1679), chap. 5, sec. 3, 128–140, on his view of the method of De Bils, and chap. 6, 140–181, for his own method.

45. Reported by G. A. Lindeboom, ed. and comp., *Het Cabinet van Jan Swammerdam (1637–1680)* (Amsterdam: Rodopi, 1980), xii, from a letter of Olaus Borch to Bartholin (which I have not yet seen), which places the event around 1661–62, when Borch was in the Netherlands.

46. Schrader, *Observationes et Historiae*, 237: "Paretur itaque vas stanneum corpori præparando quoad capacitatem aptè respondens, huic immittatur & duorum digitorum à fundo distantiâ probè firmetur craticula lignea minutis foraminibus constans, super quam corpus collocetur, mox oleum terebinthinæ infundatur ad trium digitorum eminentiam, & vas leviter ac minus arctè opertum per justum temporis intervallum in quiete servetur: Sic penetrantissimum istud oleum, cadaveris, cui circumfusum est, poris paulatim sese insinuabit, & aquosum laticem, præcipuam fermantationis ad corruptelam tendentis causam, extrudet, qui vi ponderis descendens, & per craticulam stillans, spatium inter ipsam & fundum progressu temporis occupabit; interea verò simul subtilior balsami portio, ob minus perfectè clausum vas, exhalabit, quâ magis magisque evanescente, tandem corpus concretâ olei amurcâ tanquam gummosa medullâ penitus imbutum duritiem acquiret, ac idcircò posthac extra liquorem in aperto aëre incorruptum absque situ aut tineis perennare facilè poterit."

47. Ibid., 238.

48. Ibid., 238–240.

49. Sloane MSS 1235: "Collegium Chymicum Secretum / A / D. Carolo de Maes apud Lugdunenses," 1675 and 1676: f.5, "Modus Condiendi Cadavera."

50. De Maets, *Chemia Rationalis*, 162–163.

51. Stephan Blankaart, *Neue und besondere Manier alle verstorbene Cörper mit wenig Ukosten der Gestalt zu Balsamiren* (Hannover und Wolffenbüttel: Gottlieb Heinrich Grentz, 1690). I owe this reference to Tomomi Kinukawa.

52. Dioscorides, *The Greek Herbal of Dioscorides*, ed. Robert R. Gunther, reprint, 1934 (New York: 1959), 49.

53. James Yonge, *Currus Triumphalis* (London: Printed for J. Martin, Printer to the Royal Society, at the Bell in St. Paul's Churchyard, 1679), 50.

54. Partington, *A History of Chemistry*, Vol. 2, 97.

55. Yonge, preface to *Currus Triumphalis*.

56. *Oxford English Dictionary.*

57. Yonge, *Currus Triumphalis*, 48–50. Also see William Davisson, *Philosophia Pyrotechnica* (Paris: Joan Bessin, 1640), 325–326 and William Davisson, *Le Cours de Chymie* (Amiens: Michel du Neuf-Germain, 1675), 308.

58. Partington, *A History of Chemistry,* Vol. 2, 494.

59. Ibid., 267, citing Libavius, Alchemia, 1597, bk. 21, tract. ii, c. 36.

60. L. de Bils, "Large Act of Anatomy" (1659), in *The Works of Robert Boyle*, ed. Michael Hunter and Edward B. Davis (London: Pickering and Chatto, 1999), Vol. 1; D. H. Tompsett and Cecil Wakeley, J. Dobson, historical intro, *Anatomical Techniques* (Edinburgh and London: E. & S. Livingstone, 1956), x.

61. Jan Swammerdam, *Bybel der Natuure/Biblia Naturae*, ed. Herman Boerhaave, Latin translation by Hieronimus David Gaubius (Leiden: Isaak Severinus, Boudewyn vander Aa, Pieter vander Aa, 1737), sig. l.

62. G. A. Lindeboom, ed. and comp., *Ontmoeting met Jan Swammerdam*, Ontmoetingen Met Mystici, no. 3 (Kampen: Uitgeversmaatschappij J.H. Kok, 1980), 12.

63. Swammerdam, *Bybel der natuur*: "Hier was it, in Van Hornes huys, op de 21 Januarius, 1667, dat hy de eerste reys, medwasch opvulde de vaten des Lyvmoeders van eene Vrouw, door een seer nutte onderneminge, dien hy daar naa heeft verbeterd meer, en meer." [sig C] "Hy verder oeffende vlytig een bysondere konstgreep, door welke hy de deelen der lighaamen suyver rynigde van al, wat daar in was; hier naa blies hy die op, dat sy vol lucht waren, droogde die dan; waar door die styv geworden, haare gedaante behielden, en door die konst naauwkeurig kosten beschouwd werden, jaa ook net beschreven. Eene uytvinding waarlyk van de uyterste nuttigheid."[C2]

64. Lindeboom, *Het Cabinet van Jan Swammerdam*, xvii.

65. Swammerdam, *Bybel*, sig. C: "het ruggemerg, nog warm, med de wervelbeenen, waar in her bevat is, ten spoedigsten moet gelegd in koud water, en 24 uuren daar in gelaten; waar na de wervels omsigtig gebroken moeten werden; dan werd dit alles so gesien."

66. Antonie M. Luyendijk-Elshout, "Death Enlightened: A Study of Frederik Ruysch," *Journal of the American Medical Association* 212, no. 1 (1970): 121–126; Julie V. Hansen, "Resurrecting Death: Anatomical Art in the Cabinet of Dr. Frederik Ruysch," *Art Bulletin* 78 (1996): 663–679.

Cartography, Entrepreneurialism, and Power in the Reign of Louis XIV

The Case of the Canal du Midi

CHANDRA MUKERJI

In seventeenth-century France, it was quite normal for infrastructural projects like roads, drainage systems, canals, and bridges to be carried out not through direct state action, but rather through political funding of contracts with entrepreneurs. Such structures were often deemed essential by the central government, and imposed as a duty on regional governments, but they were constructed by local engineers and laborers under the supervision of a financier, functioning as entrepreneur. Commerce and political power were allied with technical skills for material effect.

Since such engineering brought together political, technical, and commercial powers to rework the *landscape* for politicoeconomic effect, representing nature—in this case the countryside—was instrumental to the process. Infrastructural work was, almost by definition, a product of political geography. Places where improvements might be plausibly tried were identified with surveys, and the results of these projects were recorded in representations that connected the work to larger schemes of territorial integration and communication. The local political bodies that were given some responsibility for these projects also commissioned surveys to assess the feasibility of the work, address any traditional claims to the land in question, and evaluate the potential usefulness of the results. And the entrepreneurs who risked their capital in these endeavors used models and maps to design and promote their constructions, paying particular attention to the specificities of place that would affect the costs of the work (such as natural resources available as construction materials). Their engineers, in turn, used measures of elevation, distance, soil quality, and topography to choose building strategies. Some combination of commercial calculation and representation was at the heart, then, of these infrastructural efforts, and commerce itself was furthered through the cultivation and deployment of representational techniques.

How this kind of engineering depended upon entrepreneurialism and imagery in late seventeenth-century France is apparent in the case of the Canal du Midi, which was built in the 1660s to the 1680s in southwest France, running from Toulouse to the Mediterranean. It was an interesting project because it was so much more ambitious in scope than most infrastructural efforts, but it also shared so many features with them. It was as though a common system for knowing and acting on nature was blown up in scale so its social and technical contours were made more visible.

In principle, the canal was meant to link the Mediterranean Sea to the Atlantic Ocean. At Toulouse, the canal approached the Garonne River, which discharges into the Atlantic Ocean, and near Béziers the canal was to reach the sea. The structure would not only link two regions, but also two vast sea-based trading systems, making the canal huge not only in length but in possibility. More pressingly, however, such an ambitious project was technically difficult to realize. It had to cross a major watershed to link valleys with water draining in opposite directions toward two seas. Flooding the highest point of a canal in this region (particularly in the dry summers) was a difficult task—one that many saw as impossible—because opening locks to move boats would also discharge vast amounts of water. Even the port for the canal on the Mediterranean was a problem. There was no natural harbor to use, since the coast along the Mediterranean in the region tended to be flat, full of salt marshes, and easily silted up. Worse, that region of the sea was plagued by devastating storms that easily destroyed ports or filled them with run-off sand. Making a harbor substantial and deep enough to accommodate trade was not easy. In fact, it was not satisfactorily done in the period. But despite of the difficulties, a canal was built, and commerce along it followed. State-based entrepreneurialism, and representations of nature yielded a new nature—a second nature—a work of "genius" that was a tribute to and improvement upon the land of France.

We can get a better sense of how geographical representation and commercial culture met at the Canal du Midi first by studying the canal as an economic enterprise, and then turning to its development as part of a layered system of representations. With this background, we can consider more systematically links between the two.

THE CANAL DU MIDI AS A COMMERCIAL ENTERPRISE

The Canal du Midi (in roughly the form it was built) was proposed to Jean-Baptiste Colbert, controller general of finance, by Pierre-Paul Riquet, a salt tax (*gabelle*) collector from Languedoc. He was an odd man to take on this task. He was neither an engineer nor a scientist. He was not even an experi-

enced entrepreneur who had built large numbers of roads and bridges already for the state. He had, of course, a fortune and his own businesses, but nothing on a scale to match this canal. In the humanist language that has mainly typified him, he was a simple man of vision whose genius was recognized by Colbert and manifested in the canal's successful completion. More to the point, he was a money man who knew how to use finances to deploy labor power and natural resources for economic effect.

There are a number of political questions that need including in any account of the canal's success. Why did Riquet think that a powerful minister like Colbert would authorize and help him finance such a vast enterprise? Why would a tax collector (a despised social type) from a region known for its dissidents and tax revolts become capable of retaining a loyal labor force to realize his dreams? How could a salt tax collector acquire the capacity to locate a water supply adequate for the canal's watershed area, when so many others had failed? And how did a man with no engineering background imagine he could build a port to serve sailors and fishermen? Most of all, how could a man like Riquet find solutions to technical problems that had evaded the more demonstrable genius Leonardo da Vinci, who had been asked to plan a canal for this region a century before? The mythology of the heroic Riquet that haunts this bit of history raises as many questions as it resolves. But the fact of the canal's engineering remains, and so does the role of Riquet in making the venture succeed. As unlikely as the story might be, a not-so-simple regional tax man whose French was not so good did indeed propose and bring into being a canal that ran from Toulouse to the Mediterranean—not quite before his death but shortly afterward.

There were, as one might expect, indeed some good reasons for Riquet's eventual success. He could propose this project—although he lacked connections at the French court and engineering experience—*precisely because* he was a tax collector and financier. Colbert had been encouraging those with capital, such as tax men, to use their wealth to invest in infrastructural work.[1] They could enrich themselves while serving the state, and he would give them special privileges or revenue to help them. Riquet had a reliable source of income already because he was an *homme de gabelle*. Colbert simply had to give him permission to increase taxes and use that income to finance the project. At the moment he proposed the canal project, Riquet had even recently obtained a new territory to tax. The Treaty of the Pyrenees made Rousillon part of France, and Riquet was one of the few men sent to raise revenue there. Unfortunately for him, however, since Catalonia had no traditional salt tax, violence erupted in Rousillon when it was imposed, leaving Riquet angry and with very little additional revenue. His attention to the dissidents in the region became a sore point with Colbert when the minister thought Riquet was spending too much time in the Catalan city of

Perpignan and away from the canal. Still, when the project was first proposed at Versailles, Riquet's position as a tax farmer (and proven skills at raising money) made him a more attractive candidate for this commission.[2]

Colbert, of course, did not simply share costs with Riquet, using treasury funds. He exercised his political muscle to extract financial contributions from local political authorities, mainly the États de Languedoc. He used also the power of the state to acquire the land for the canal, set down principles for assessing the value of the properties, and force local authorities to help with the financing of their acquisition. The minister additionally signed edicts setting price limits on construction materials and their transport to the canal; he ordered the roads in bordering towns to be improved; and he gave Riquet mining rights in nearby mountains—presumably to make him his own supplier of iron for the locks. Later in the process, he also (and more reluctantly, against local opposition) supported the sale of (lucrative) offices related to the canal's administration, which gave Riquet a new revenue stream for the project.[3] Colbert even authorized the imposition of a new tax on public houses, inns, and bars in the region (perhaps because they were profiting so much from the workers), and required nearby towns to house the workers at local expense.[4]

These schemes for financing the canal's construction were both Colbert's ways of orchestrating the state's participation in the work, and the tax man's ideas about how to make his investment work. Just as much as Colbert tried to control Riquet with his favors, the entrepreneur extracted from his patron means for financing and managing the project. Riquet knew the limits of state influence in his region, and let the minister know when Colbert needed to enforce his edicts or extend his list of required contributions from local authorities. The tax man also was the one to notice when suppliers were price gouging, and he asked for legal relief from these practices. The assiduousness with which Riquet attended to his financial interests may have raised Colbert's suspicions about the tax man's true interest in engineering. But the record suggests that both men used their own forms of financial experience to make the project work. Riquet (an extractor of local revenues and creator of economic opportunities) was skilled in recognizing where money could be found, natural resources exploited, and labor power put to work for politicoeconomic advantage. Colbert was good at recognizing political and economic opportunities for the state, and using political incentives to promote them and reduce their risks to the treasury and the reputation of the king. Both men needed all their wits to keep up with the rising costs and risks of the project, and despite their mutual distrust they managed to make their alliance work.[5]

For dealing with local elites and resources, Riquet had family connections and associations forged through his work to keep his authority intact against

the powerful opponents who tried to block his efforts. Local hostility to the project was predictable. Confiscating tracts of estate properties from landholders and demanding large sums of regional tax revenues on top of this—particularly to finance a canal that would (in principle) yield personal economic gain—was unlikely to appeal to stakeholders in the region's economic arrangements. But Riquet had connections in this group and was schooled (if not always skilled) in local politics. His father had been a member of the États de Languedoc—even when an earlier proposal for a comparable canal had been evaluated and rejected by the local authorities. He was aware of the foot-dragging that was endemic to fund raising for state-sanctioned projects from the États. But he was also trained in making people give up the money they owed him—against their will. The elites of Toulouse, Carcassone, Montpellier, and Béziers may have been more visible and powerful than the persons who usually owed him tax money, but once Riquet had Colbert behind him, he had the political connections that could (at least at times) intimidate them. The tax man also cultivated a loyal cohort of supporters for his scheme among these powerful men. He recruited as investors many leading politicians, financiers, landowners, and entrepreneurs, making loyal advocates for his engineering scheme from this group of local elites.[6] These were allies he desperately needed and too frequently alienated as the work progressed and as the list of his local enemies grew.

No skill in political maneuvering was of any value to Riquet, however, until he first persuaded Colbert to endorse the project, and this was no simple task. But he had a trump card. He lived in a land known for its tradition of religious heresy, tax revolts, and antagonism toward the central French state. French troops had been so frequently called into Languedoc (since the Wars of Religion in the sixteenth century) that the region was better mapped (from military surveys) than most other parts of France. The region was mainly peaceful in midcentury, but the nobility in southwestern France of the seventeenth century remained Huguenot, and Protestant ranks seemed to be increasing in size and power. In this context, Riquet chose as local patron for the canal project (the man he hoped would bring his proposal to the attention of Colbert) d'Aglure de Bourlemont, who was about to become the archbishop of Toulouse. This respected cleric agreed to inspect the plans and engineering mock-ups for a canal already set up by Riquet at his estate at Bonrepos. He was impressed enough with what he saw to take the proposal to the very Catholic court at Versailles, and to the minister himself.[7]

Colbert had other than religious reasons to be predisposed toward this tax man and the proposal introduced to him by d'Aglure de Bourlemont—politicoeconomic ones. The minister was already strategically placing new commercial ventures in dissident regions to create a permanent state presence, and Languedoc was on his list of sites with economic assets but need-

ing better control by the crown. Riquet was a good agent for Languedoc. He had financial skills, knew the land from firsthand experience, was not a dissident, and was more than willing to function as an informant about the activities of locals that he deemed threatening to his interests and state power. Important, too, was the fact that he was willing to risk his fortune in a commercial project of imposing scale that might indeed make his fortune but could also serve the regime. If the canal were built, the propaganda value of the structure alone would be enormous. Early in the project, the canal even seemed to have strategic military appeal. The great military engineer Vauban argued that the waterway could be made wide and deep enough to carry military vessels from the Mediterranean to the Atlantic, thereby avoiding pirates by Gibraltar—a great problem for the French navy. Although this military dream was soon scrapped, the political value of the canal remained high.[8]

Infrastructural improvement also had a particular political resonance in seventeenth century France. The *mesnagement* tradition of politics in France—which defined the state as a great estate that needed proper management[9]—had put great emphasis on strategic use of the countryside as a route to collective wealth and power. By using rational land management practices, one could (according to this political theory) yield a landscape that was more Edenic, and that would allow the people in rural areas (rich and poor alike) to enjoy greater prosperity, increased trade, and more stable social relations. The canal was easy to identify as just the kind of improvement needed in the countryside to make it more perfect—a water system that was less prone to flooding and the strong currents of local rivers and streams. Linking the Mediterranean to the Atlantic through such a peaceful waterway was not only a way to increase trade, but—in theory at least—create a better political environment. Trade, of course, was meant to be a clear benefit of the canal. The economies of the Atlantic and Mediterranean areas were so different that there was every reason to think that demand for goods that could be moved through the waterway would be strong. The canal's construction in any case made the countryside around the structure more of an economic asset, and placed the pursuit of trade into the visual field of all those who lived by it, suggesting new possibilities for commercial activity.

Riquet's strategies for managing the work process also impinged upon and added a new commercial element to local social arrangements. The canal was constructed using an innovative and unusually generous wage labor system. In some sense, the contractual labor force he raised to build the canal helped to constitute a working class in this area at a very early moment. There were roughly forty thousand people who participated in the construction, giving this region a surprisingly extensive set of capitalist social relations.

Riquet paid and treated his workers extremely well because he was a money man and knew the power of the purse to deliver what he wanted. But he also needed some way to attract a stable labor force for this vast project. If locals were inclined to hate the tax man who (at least nominally) directed the project, they did not object to sharing his wealth. The pay scale at the work-site was something of a scandal, since common laborers were paid half again what they would be given for farm work. They also could take sick days off and were paid for periods of bad weather, when it was physically impossible to work, and even holidays. This regularity in compensation was practically unheard of in the period, even in Paris, much less among laborers of Languedoc.[10] It is true, as Le Roy Ladurie has pointed out,[11] that the peasants of this region were already independent farmers rather than serfs in the thirteenth century, suggesting that there were long-standing modernizing forces affecting labor relations in the region. Still, Riquet's labor contracts were revolutionary, and shocking enough to his contemporaries that they raised questions about his character and honesty. Local nobles who opposed the canal apparently suggested that Riquet was only claiming to pay such high wages so he could actually pocket more money for himself. That is one of the main reasons Colbert sent a trusted confidant and engineer, La Feuille, down to check on Riquet, but there was no evidence of impropriety. La Feuille's reports back to Colbert were, on the contrary, quite clear that many expenses of the project were legitimately large. Wages were eventually cut, but not to the level of local agricultural labor.

It should be no surprise that nobles objected to Riquet's labor policies. Field hands and shepherds from local estates constituted the bulk of the workforce, and nobles lost power over the laboring poor because of Riquet's contracts. Moreover, the tax man did achieve surprising loyalty in the workforce. Even when Riquet raised taxes to supply more revenue for the canal and there were movements against paying the *gabelle*, the workers did not rebel against him.[12] The stability of the workforce meant that the experience gained from early efforts to build the canal was not lost by exhausted and disaffected workers who left to seek employment elsewhere. It was carried over to the next stage of the project by those who liked the pay scale and work rules. For a canal that was so complicated to achieve, this kind of continuity was very valuable; creating a stable workforce was a good investment.

Given the entrepreneurial logic behind the proposal for the canal and the process of its construction, it is surprising, in the end, that Riquet sought as his reward for this work *not* commercial rights to the canal's use, but domainal rights to the land on which it lay. Riquet demanded (no matter how inappropriate it seemed to Colbert) to create a landed family of title through his entrepreneurial skill. In this region of France, where the well-being of the household (as Le Roy Ladurie has suggested in *Montaillou*) was

the central cultural value, this probably made sense. Colbert expected social mores akin to those of the Parisian bourgeois elites, who bought domains with their profits rather than demanded domains as part of a contract. But Riquet was not from Paris. Because of his stubbornness on the subject, Riquet infuriated Colbert, and lost the support from the treasury for the second stage of the project, but his household was indeed given as domain a long, thin stretch of land that meandered Toulouse to the Mediterranean.[13]

In the end, Riquet brought to the engineering of the Canal du Midi not technical expertise and probably not personal genius, but financial experience in extracting resources and creating a loyal workforce that could learn on the job. He was not a thoroughly modern man of finance, but he was an entrepreneur who was clever with contracts, and he respected the expertise of others (even laborers). He used the canal as a means for making a commercially more tractable "second nature" whose profitability would better serve both the interests of his family and the glory of his king.

THE CANAL DU MIDI AND LAND SURVEY METHODS

Cartographic skills, survey measurements, and other means of representing the landscape were invaluable for this project, but less as a source of accurate *information* to shuttle between bureaucrats at Versailles and entrepreneur/engineers in Languedoc than as tools in an ongoing system for learning about and solving problems of land control.[14] The distinction is important. We often assume that states need information, and that they acquire it by deploying experts who feed bureaucrats with the kinds of information they need or want to make administrative decisions. But a project like the Canal du Midi could not have been developed around the formal knowledge of geography in the region, and the engineering depended on a continued pattern of problem solving. Subtle characteristics of the topography, soil, watersheds, and the like became more apparent as the work progressed, and had to be taken into consideration. New information about the project was gathered at every step in the project and pointed to problems that had not been anticipated in the plans. Of course, *good* data were vital. The more accurate the information at any stage of the process, the more useful it was to the outcome. But the most important thing to the project was the capacity to learn—to engage in ongoing decision making and problem solving. Accurate information about how to build a channel through one part of the landscape was useless if the canal was finally routed elsewhere. The project needed good maps of the area to help route the canal correctly, but it needed even more the capacity to survey and assess in complex and changing ways whatever portion of the landscape required engineering attention.[15]

The primary problem for Colbert (as the political patron for the project) and Riquet (as the entrepreneur investing his family's wealth and future in the scheme) was risk. This was an attractive venture that would clearly have enormous benefits if it could be realized, but the "if" was very large. Projects of this sort had been proposed for centuries, but they had not been realized because of technical problems. Certainly Colbert had no interest in undermining the reputation of Louis XIV by sponsoring a project of this visibility that would fail. (The military's later efforts at the Eure River aqueduct would do just that in the 1680s, but Colbert was much more averse to risk than was Louvois or Vauban.)[16] Riquet, too, had no desire to waste all of his personal strength and financial assets. But this was not a project that was guaranteed of success. By all accounts, it was too difficult to achieve. There was no one person in France who really knew enough about the huge area that the canal traversed or enough about canal engineering even to say whether this scheme was practical and whether Riquet's plan was feasible. Instead, the major actors accepted the risk and took a leap of faith in supporting the canal project. What made them do it? One plausible explanation is that they had multiple mappings of this region that made them feel they knew the local countryside and what to do with it. They had canal plans, road maps, military surveys, maps of water sources, and legends about the local landscape. This array of formal and informal representational systems for rendering the countryside not only yielded large amounts of information, but a set of perspectives on land which addressed a surprisingly broad range of human needs and interests.

The growth of humanist geography in the sixteenth and seventeenth centuries had already provided in western Europe a particularly rich set of cartographies, emphasizing human material achievements on the land (cities, wall systems, ports, canals, roads, bridges, monasteries, managed forests, territorial boundaries, and property lines). These images provided a wealth of evidence that human beings could indeed rework the landscape for commercial and political effect.[17] The problem with these maps as guides to building the Canal du Midi is that they were developed by *different* groups with *distinct* ways of measuring, recording, and acting on the land. To reduce the risk of the project and actually create the canal, these distinct *visions* and *traditions of practice* had to be combined. Colbert and Riquet—for a range of reasons—succeeded in doing this, creating a social learning system that allowed experts to bring different ideas into the project. The ironic result was that in this period of so-called state absolutism the solution to the material problem of territorial control lay not in centralized and absolute control of the engineering process, but precisely its opposite: the development of a system of distributed learning that allowed diverse strands of surveying and engineering to be combined for a common purpose.[18]

There was a range of skills in geographical measurement available in France used for representing and acting on the natural world. Measurement techniques for making elevation studies with precision were taken from men of the Academie des Sciences; mapmaking repertoires developed by military engineers for planning battles and building fortresses were used to manage the canal's incline, build reservoirs, control water intakes, and design the canal basin and some aspects of its locks; civil surveying techniques from road engineering and property disputes were employed to manage the land acquisitions for the canal, help build the bridges, and design the route; and geographical folklore and traditions of practice from the region identified places to avoid or use in planning the canal and acquiring resources for its construction.

Military surveys were the most frequently employed forms of scientific cartography in France during the early modern period. Maps of coastlines, cities, strategic canals, and drainage projects, mountainous areas and roadways were important strategic tools that took advantage of the measurement techniques being refined in the period. There are thousands of unsigned maps made for building fortresses, planning sieges, setting cannon, deploying troops, re-creating battles, and describing terrain in border regions that remain obscure testimony to a widespread practice. The maps were a clear form of political cartography, obsessed with details of the local landscape that could affect the army's ability to control it.[19]

Military cartographers, whether engaged in fortress engineering projects or planning how to move troops or set up cannon, learned to think primarily topographically. Topographical features of the landscape were natural barriers and conduits, so they had vital strategic importance. Fortresses reconfigured the topography artificially, using walls, ditches, and canals to constitute a new terrain. A set of high bastion walls with a canal between them was (ideally) an artificial version of a deep gully surrounded by mountains and filled with a daunting river. Army engineers and surveyors who helped in mounting sieges, tunneling into the battlement walls and rolling temporary bridges across streams or canals, were in the process also erecting a countertopography of their own. No wonder military surveyors became particularly adept at measuring the subtle changes in elevations that gave character to local regions.[20] A comparable refiguring of the landscape was precisely what Riquet proposed to deliver with the Canal du Midi, and what Colbert hoped to bring to fruition when he sent Chevalier de Clerville, France's leading military engineer, to evaluate and oversee the project in the name of the state.

Also during the reign of Louis XIV, Colbert stimulated and set apart scientific cartographic work when he established the *Académie Royale des Sciences* and the *Observatoire*. The point of these institutions was to promote the

sciences in France. To be a center of European civilization—to rival or even eclipse Italy—France needed to be a leader in the sciences as well as the arts. A French system of academies, based on Italian precedents but better funded and organized, seemed the best way to surpass the Italians.[21] Unlike the military surveyors who worked in a range of locations but still paid greatest attention to the peculiarities of a particular place (for obvious strategic reasons), the mathematicians of the academy reduced all lands to planar measurements. The point was to increase the accuracy of simple measures, not try to account for geographical complexity. This was still valuable to an engineering project like the Canal du Midi because the canal would work only if the elevations were accurate enough to create a stable water supply and build a viable system of locks. That is why the commission that first inspected the area under the direction of Clerville used academic techniques for taking elevations to check on Riquet's claims.[22]

The least studied of the pertinent survey traditions of the period was the kind of simple measuring done for plot plans, resource assessments, or civil engineering projects. This genre of mapmaking became a routine political tool for policy making under Henri IV, when infrastructural improvements became important to state policy. Rational land management techniques of the sort used on individual estates were applied to state policy to promote the economic well-being of the kingdom. This political approach put great emphasis on knowing the countryside as a repository of natural resources and site of potential improvement. Surveying and engineering were closely aligned as political tools. Although this strategy seemed to be buried along with the Protestant King Henri IV, the politics of *mesnagement* was revived by Colbert in the period of Louis XIV and became part of the territorial politics used to serve state-based absolutism. This gave civil, forestry, tax, and estate surveyors new work and social importance.[23]

These surveyors did not place their findings in grids of latitude and longitude like Cassini and Huygens. Like the academicians, the *arpenteurs* paid less attention to topography than the military surveyors, but similarly cared about the specific characteristics of local areas. Like *géographes du roi*, they were called upon to address the political status of land holdings, but unlike all the rest, they acquired skills in resource assessment and worked on civil engineering projects with local entrepreneurs. They were the ones attentive to road construction, forest management, estate planning, and hydraulic engineering—techniques of land improvement. This kind of localism, so different from that of the military, was obviously essential to the building of a great canal like the one from Toulouse to the Mediterranean.

The least scientific of local means for representing the land was not a form of survey at all, but regional narratives describing places. Folklore might have seemed to have no place in a process of "rationalizing" the land-

scape through engineering, but that was not the case for the Canal du Midi. Stories about the countryside as a site of spiritual as well as natural powers were crucial to understanding where to build a tunnel or how to recognize the exact position of a watershed. Stories marked sites of natural anomalies and indicated where human (or superhuman) forces had changed patterns in nature. This region of France, as part of a pilgrimage route to Campostella in Spain, was particularly rich in sites of miraculous streams, devilish rock formations, and stories of saints and heretics. This region of France had also been an important part of the Roman Empire, and stories of past glory made visible the webs of roads, canals, bridges, and burial sites from this early period that could be used a models for construction of a great canal. Narratives of place, then, were means of representation that carried local knowledge about the character of the local countryside, and passed on understandings of the natural world and past engineering ventures that were important to the Canal du Midi.

RISK ASSESSMENT AND REPRESENTATION AT THE CANAL DU MIDI

There were two major problems that plagued the project for the Canal du Midi, which made the risks of trying to build the canal sometimes seem too great to be worth trying. The first was the alimentation system for flooding the high point of the canal. If the canal could not be supplied with water, it could not be built. The other was the port on the Mediterranean. If the canal could not link trade on the Garonne River to trade on the Mediterranean, it had less purpose in propaganda value and economic usefulness. The definition of the canal as the Canal des Deux Mers—the canal of two seas—depended on finding solutions to these two fundamental problems. But the project was begun without either of these problems being fundamentally resolved. The canal was started when the problems seemed soluble, and Riquet seemed able to solve them—with the kind of help and supervision that Colbert insisted upon for the work. What made these problems seem no longer real impediments, but rather practical issues to work through on the ground, was a demonstration that diverse groups of experts could be deployed to fashion solutions.

For the first stage of the project, when the water system was in question, Riquet developed his scheme by assembling his small cadre of experts to guide him, and Colbert tested his capacity to do the work by setting up a commission of diverse (and much more powerful) experts to challenge and refine Riquet's proposal. At the second stage of the project, when the port and routing of the canal were more pressing, Riquet (already used to but annoyed with Colbert's continual stream of spies/experts coming from the

north) enrolled all those who came to assess the project in thinking through the problems. He allowed or even encouraged in this period a much more fluid social arrangement of participants, and gave more autonomy to those working at different sites. He also took more risks in the project itself as he became confident that the engineering process would finally yield a canal. In these ways, the project clearly changed in its second stage. But the result was still a pattern of distributed problem solving and group learning, using diverse means of representing land to act on it.

The water system. The first great obstacle to building this canal was designing a water supply system that would flood the high point of the structure, and the basic system for the Canal du Midi was designed for Riquet with help from Pierre Campmas, a *fontainier* from Revel, a small mountain town where Riquet had some land and financial interests. A *fontainier's* job was to find water supplies for the town and get them where they were needed. This work entailed subtle knowledge of local topography, some hydraulic engineering, and experience with seasonal weather patterns. The *fontainier* had already worked for Riquet, diverting water to a mill on his property, so Riquet was aware of his expertise.[24]

Campmas was able to reduce the risk of a water shortage for the canal because he understood so much about the water supplies of the Montagne Noire. He also knew how to follow the topographical contours of the landscape, designing conduits for carrying water safely downhill to where it could be used. He already knew the rivers on the mountain and the gorges that could be dammed to collect water during the rainy season.[25] Still, Campmas was in no position to think about how to design a water supply system for a large canal. He could deliver water and build supply channels, but he had no way to know if the supplies would be enough to keep vessels afloat in the summertime. He could not compute the amount of water necessary for a canal because he had no experience in assessing how many locks were appropriate for a particular incline. Without an educated guess about the number of these structures the canal would need, he could never estimate the amount of water the canal would require to stay filled when it was in use and the locks were dumping water downstream. So his expertise alone left too much unknown to make the project seem reliable enough to fund and try.

The adequacy of the water supply could be better estimated, however, with the expertise of a hydraulic engineer like Riquet's other collaborator, François Andréossy. Andréossy had no local knowledge of the watershed, but he was trained in principles of surveying and engineering. Moreover, he had recently visited Italy, where he inspected some of the well-known Italian canals. He could consider the number of locks needed for the Canal du Midi

and thus the necessary water supply (although he vastly underestimated the eventual requirements), so he could assess the results of Campmas's efforts. He was also a fine cartographer, so he could represent the proposed canal and its relationship to the region in which it would be laid, not only showing its route but suggesting its fit with the local topography. Thus, he made the canal project seem conceptually viable and strategically visible in ways important to gaining the confidence of Colbert and the king.[26]

While these three men were individually in no position to think through the construction of this large canal, together they had the expertise to make the project seem feasible. Riquet could calculate finances, Campmas could find and direct water from the Montagne Noire, and Andréossy could design the structure and define its technical requirements. Still, the three had little social standing and no obvious authority for making such a grand proposal. Their solution was to build a mock-up of the canal on Riquet's estate at Bonrepos to test their engineering designs. They had two little ponds for a water supply, a set of locks, supply channels, and even a tunnel to take the water downhill and through the mock canal. If anyone doubted that these men could actually construct a canal, this was their answer. The team had already made such a construction—at least on a small scale. It was a matter of demonstration, not dispute. Riquet showed the model to the future archbishop d'Aglure de Bourlemont, who then brought Riquet's plans to the attention of Colbert.[27]

Colbert was interested in, if not convinced by, Riquet's proposal and sent Clerville to assemble a commission of experts to study Riquet's plans. Under Clerville's supervision, this group was to travel through the Montagne Noire and along the proposed route of the canal, making surveys and assessments of the engineering proposed by Riquet, and then report back to the minister.[28]

The commission had the social authority that Riquet, Campmas, and Andréossy did not. It included many local notables who had no expertise in canal construction, but who, like Bourlemont, were necessary to secure political support for the enterprise. The "experts" on engineering and surveying on the commission were, first, Clerville himself, with his experience in building fortresses, including canal construction (at least over short distances). Next there was Henri de Boutheroue de Bourgneuf, whose father had completed the Canal de Briare, linking the Loire to the Seine,[29] and who himself now managed that canal. As the man with the greatest practical knowledge about comparable waterways, Bourgneuf was expressly charged with estimating the amount of work it would require to build Riquet's project, and what it would cost. In addition, there was the sieur de La Feuille, an *ingénieur* who seemed to have the trust of Colbert, and who was put in charge of supervising the canal work from 1667 to 1683. The group also included four *niveleurs*, two of whom are known: Riquet's colleague

François Andréossy, and Jean Cavalier, a *géographe du roi.* Cavalier had started in the military, but he had become a skilled regional cartographer, drawing the region's best map, one that was repeatedly copied and reproduced for almost a century.[30] The other two surveyors, whose names do not appear elsewhere in cartography, presumably had some local knowledge and civil survey skills. This meant that the commission contained not only members of the region's political elite but established experts in the intellectual traditions pertinent to the job. The survey team included a civil engineer/surveyor (Andréossy), a *géographe du roi* (Cavalier), a hydraulic engineer (Bourgneuf) and two military engineers/surveyors (Clerville and La Feuille). There was no academician, but the elevations made by Cavalier were done using the techniques developed by La Hire, one of the most able surveyors from the academy, so even academic surveying had its effects on the development of the plan.[31]

The members of the commission trained in different traditions of French surveying and engineering not only tried to anticipate and reduce the risks of the venture, but also checked the assessments made by the original team. Riquet's financial expertise was set against Bourgneuf's experience at the Canal de Briare; Andréossy's designs for the canal and reservoirs were checked by Clerville and his assistants for their soundness; and Campmas's water supply plans (as well as the overall canal trace) were scrutinized by Cavalier, Bourgneuf, and La Feuille to see if the inclines were well computed and the routes topographically well placed. The commission members did not so much challenge the plan as revise it to make it more effective, apparently reducing the risk of this daunting but intriguing project. [32]

Since the crucial risk facing the commission had to do with whether the water supply system would be effective in supporting a navigational canal, delivering adequate supplies when and where they were needed, the commission spent most of its time considering this issue. One important element in the plan had to be the location of a watershed where the supplies could be delivered to the canal to flow both toward the Atlantic and toward the Mediterranean. Although historians have sometimes admired Riquet's skill in swiftly locating the watershed between the two river systems linked by the canal, in fact there was little argument about where to do this. There were known watersheds in the area, the best recognized of which was La Grave de Naurouze. These were represented less on topographical maps than in folklore. Riquet and his colleagues simply confirmed with their elevation studies what was already common conjecture among locals.[33] The problem was not finding the watershed but making a convincing case for its usefulness for the project. Physical geographers, following Hondius, generally believed that mountain chains existed between all major river systems. In fact, many period maps of southwestern France actually depicted a set of

mountains running through the proposed route of the canal. They were fictional constructs, theoretical assertions, unbased on measurements or observations of any kind. But they had the authority of respected science.[34] So, much of the effort of the survey work was *nivellement* or studies of elevation to prove that the canal could in fact be built across the proposed set of valleys and be supplied with runoff from the Montagne Noire carried to Naurouze. Given the serious problems of scientific credibility of the project, it should be no surprise that the surveyors, apparently under the tutelage of Cavalier, the *géographe du roi*, used La Hire's measurement techniques for the commission's elevation studies. This gave their findings the authority of science, so that they could be trusted as a basis for countering Hondius.[35]

Even with good elevations, however, the plan for the water system was so complicated that it was not entirely convincing on paper. This is why the commissioners also asked Riquet to make a channel along the proposed route from the Sor River (on the Montagne Noire) to the Fontaine de La Grave à Naurouze. This *rigole d'essai* was meant to be a small ditch just to prove the inclines, but it was nonetheless built with some difficulty. Torrents of rain kept disrupting construction of the *rigole*, but in October 1665, the waters arrived as expected at Naurouze, and the demonstration of the alimentation system was complete.[36]

The result of the commission's studies on the Montagne Noire and the test of the water system with the *rigole d'essai* was not only an engineering plan for the alimentation system, but also confidence in the canal scheme itself. The risks entailed in designing a canal that crossed a watershed, which had impeded the development of such a waterway in this region before, now seemed small enough to face. Once the commissioners endorsed Riquet's proposal (with their revisions), Colbert was willing to give out a contract for at least the first stage of the process. He authorized beginning the canal at Toulouse, connecting it to the Montagne Noire supplies, and carrying it (with an impressive set of locks) across the watershed. Completing the work to the Mediterranean would have to wait until another set of vexing technical issues were made less daunting.[37]

The Port. The port of Cette or Sète, built as the terminus of the Canal des Deux Mers, was in some ways the exact opposite of the water supply system on the Montagne Noire. While designing an effective complex of reservoirs and ditches in the mountains to deliver water to a faraway canal seemed an obviously difficult engineering task, an outlet for the canal on the Mediterranean appeared relatively straightforward. Building breakwaters and dredging harbors might not have been simple ventures, but they were at least more familiar ones.[38] The risk of diminishing the effectiveness of the canal by giving it no good port at one end seemed small at first, but it loomed

larger as the work progressed. To offset the anxiety that resulted from repeated failures of the seawalls and dredging, more and more information about the site was accumulated and discussed by different kinds of experts. The representations of Sète multiplied, providing new hopes for solving engineering difficulties that seemed intractable. By the time the difficulties at Cette had become chronic there was no way to reroute or stop work on the canal. It was already too far advanced. The point was to reduce the risk to the canal's success that a poor port would create, and to increase the chance of making the whole enterprise into the flourishing and politically dramatic system that had been imagined. Each new layer of representation was accumulated to achieve this end, and gave new reason to revive this hope.

Importantly, thought had already gone into the construction of a new harbor in Languedoc even before Riquet first sent his original proposal to Colbert. Clerville had been asked to survey the coast near Béziers to propose a way of constructing a new harbor. He suggested building one at Cette or Sète. The engineer was given this task because for both military and economic reasons; having no safe harbor in this area was a strategic problem for France. Colbert was concerned on both grounds because not only was he finance minister and worried about the French economy, but he was also in charge of the French navy (such as it was). His success in empowering the state, pleasing the monarch, and satisfying his own sense of order depended on making some improvements in this area.[39]

The southwestern region of the country was also among the richest in foodstuffs and manufactures, but poor in transportation. The population (in this period before the Revocation of the Edict of Nantes sent the industrious Protestants in large numbers to the Netherlands and England) was relatively large and productive. There were textiles and leathers being produced in the Montagne Noire. There were marbles and wood to be extracted from the Pyrenees. And wine and other foodstuffs were produced in excess in the rich inland valleys. All these goods could find new and more profitable markets if they could be transported along the Mediterranean.[40] But the sea was full of pirates, the storms in this area frequent and intense, and France was a country too weak in naval power to support a merchant marine without a better infrastructure. The lack of safe harbors was simply dangerous. For these reasons, Colbert had asked Clerville to survey and design a new harbor somewhere to the west of Marseilles. Near Agde, a large rocky hill rose from the otherwise flat and sandy coast. This appeared to be the only natural barrier in the region that could be used to protect ships from storms. The hill was also strategically useful. The promontory provided a site to look out for enemy vessels coming to attack ships in harbor. On the inland side of the hill, there was also a large and relatively deep étang or marsh where water already collected naturally. It seemed possible that dredging this area for a

harbor and providing a more substantial barrier between the sea and interior with a well-designed seawall could yield an effective new port. Clerville was already planning this project when Colbert asked him to head the commission to study the Canal des Deux Mers.[41]

This helps explain why, when the commissioners were reviewing the plans for the canal route, they recommended constructing a new port on the Mediterranean just where Clerville had wanted it. It was immediately obvious to him (and perhaps to Colbert before him) that Riquet's canal could be connected to Clerville's port and help serve doubly Colbert's plan for stimulating trade in the region. It also seemed possible to Riquet that if he could construct and have a fundamental economic interest in a vital new French port, he could become an even richer man and safeguard his family's future better than he could with the canal alone. In turn, if Colbert could give this project to Riquet to complete, he would not have to use so much treasury money or become too reliant on the military engineers for realizing his economic policies. (Keep in mind that Colbert and the minister of war, Louvois, were rivals and even perhaps enemies vying for the king's ear and limited resources.) The project seemed a way to reduce risk for both the minister and the tax man. The canal would give more commerce to the port; the port would make the canal a more effective trading route; Riquet would risk his fortune and reputation; and Colbert would create a whole new trading system that would be a wonder of the world and an asset to the French navy.

Unfortunately, dreaming of a new harbor was quite a bit easier than actually building one along this coast. Silt in local rivers and the storms plaguing the Mediterranean in this area made the easy discharge of the canal and its cargo into the Mediterranean more problematic than anyone had thought.[42] Creating a large seawall to enclose the entrance to the harbor was itself a difficult task, but knowing how to design it was more taxing. It had to be constructed so that high seas would not damage ships during storms, vessels could move easily in and out of the harbor, and sand could be normally discharged along with outflows of water from rivers and streams. Because the mouths of existing rivers that ran into the sea produced no natural harbors in this region, there were some fears about the silting up of the new port. But no one at first realized what a persistent problem this would be for Sète.

The reason that the silting problems were not well anticipated for the port was that there was no equivalent to Campmas for the harbor. There were no local harbor masters to consult on design because there were no natural harbors. In the other parts of France where harbors (mostly on the Atlantic) had been improved through engineering, the expertise that had been accumulated in the process was not useful to transfer to Sète. First, the problems of engineering on the Atlantic were substantially different, and

second, these harbors tended to be part natural as well as engineered, which the port of Sète simply was not.

Riquet grew up in Béziers and was good at imagining the *town* he would build at Sète to make it a great depot; he knew how to design a major center of wealth and power. But he had no obvious solution to the problems of designing and building the port, and he was spending a great deal of time in Perpignan rather than Agde. Nonetheless, he became impatient with Clerville, La Feuille, and others sent by Colbert, who had their own ideas about the harbor and felt authorized to speak their minds. Colbert was writing to him as the man responsible for the success of the venture, but he was also not letting him make the decisions. The result was another nightmare of diminished control for Riquet. But it also set up a new system of distributed cognition for addressing the problems of the port—using different traditions of land representation and design. In the end, this situation also gave Riquet allies when Colbert abandoned him. La Feuille and Morgues could speak authoritatively about Riquet's honesty and real need for money to complete the work.

The experts consulted on the port brought a range of skills to the task: knowledge of mathematical technique (the Jesuit Père Morgues), Dutch and Italian traditions of hydraulic engineering (La Feuille), military engineering (Clerville), and land management/building techniques used by local surveyors and entrepreneurs in the region.

The authority for the work was as layered as the representational techniques used on site. Riquet, of course, was now sure that he was a world-class engineer, and lost no time in telling Colbert that he should be given more control of the work. Colbert, who was increasingly concerned about costs and the losses that resulted from earlier mistakes of measurement and design on the canal, was not so impressed, but still needed the entrepreneur to deliver on this project. Clerville, in turn, felt he still had the commission of building a harbor in Languedoc, and knew more about this kind of operation. But he was often called elsewhere to work, and this left La Feuille and Riquet to share primary authority. When the problems with the port were mounting, La Feuille was sent first to Holland and then Italy by Colbert to see how more experienced engineers worked with comparable situations.[43] Colbert then insisted that Riquet not proceed on the port until La Feuille brought the results of these study trips back to Languedoc. This rankled Riquet, and locked the two men in a struggle for power that deprived both of them of control.

It is important to notice that unlike the group who worked on the water system for the Montagne Noire, the men charged with creating Sète included a military engineer, a school-trained engineer, and a mathematician, but lacked a man like Campmas. There was no one from the area who

had routinely worked on local harbors, knew the coast intimately, shared local narratives of place and used these strands of knowledge for engineering. The closest equivalent this group had was an odd outsider, Louis de Froidour.

Froidour was one of the most unlikely contributors to the port design because he was France's leading forestry surveyor, not an engineer or local fishing or shipping expert. But what Froidour could provide were a set of ethnographic techniques that he used to learn insider, local knowledge about the place where the harbor was being built, and characteristics of the sea that impinged on design. The first problem in designing Sète was defining what local fishermen, merchants, and sailors thought would make a good harbor, and what they understood about the problems in building it. Froidour then recommended design changes based on what he heard.[44]

Interestingly, Froidour seemed to have been called to the canal site originally not to study the port but to look at the water system in the Montagne Noire, where he wrote enthusiastically about the great dam being built at St. Ferréol, and the ingenious system of ditches constructed to carry water to the Seuil de Naurouze. Froidour was not particularly informed about the region or even its forests. He had until this point in his career been busy mainly in the north inventorying the timber reserves there. He had just been called to the south by Colbert to map the much more dramatically depleted forests of this drier region. He was the forestry surveyor whom Colbert trusted the most, but not because he was such a mathematically adept surveyor or knew the forests personally. It was because he was deemed an honest man who sought accurate knowledge more than bribes. His trip to the Montagne Noire made sense as one more instance of surveillance orchestrated by Colber, both resulting from and underscoring the minister's insecurity about the water system. Froidour was a good spy for Colbert to assess the technical work because the forestry bureau was actually the office of water and forests. When he measured France's forests, this often meant Froidour was studying mountainous areas in which large timber trees grew and rivers ran downhill that could carry logs to towns. Additionally, as an "honête homme," Froidour was also a good person to check for signs of impropriety. A large part of his forestry "surveying" was really interviewing people about where old forests had gone. If there was nothing to survey where a forest had been, or an old forest was much smaller in the surveys than it appeared to be in old maps, Froidour was charged to determine who had done the cutting, what taxes they owed on the profits, and what fines they should pay if they cut trees for which they had no authority. He was, then, someone whose job was in part to locate and document improprieties and punish transgressors. These were fine credentials for a spy sent to the Montagne Noire.[45]

While it made sense for him to inspect the water supply system, Froidour was not someone who had any apparent experience in building ports. But his skills as a kind of ethnographer — someone who could acquire local knowledge about places and their uses — made him the next best thing to Campmas. If he had no firsthand acquaintance with local understandings of the coast, the problems with storms there, fishing practices, uses of and seasonal changes in the marshes, and the effects of the rivers discharging into the sea, he was at least experienced in taking oral testimony from local populations (*procès verbaux*). Froidour had learned how to ask pertinent questions that would reveal patterns (good and bad) of resource use.[46]

Froidour interviewed sailors and fishermen about the sea, its character, and uses in the region. He talked to them about why the rivers there had dug no natural harbors into the sea. He learned in what direction the winds blew during the fiercest storms to make sure the port would be designed to provide appropriate protection for vessels in the harbor. An early storm proved the potential protection of the seawall, but later ones were more destructive, raising questions of design that Froidour could address. Through his efforts, he brought more of the local, folk (and oral) representations of the area to this part of the canal's design and construction.[47] Unfortunately, no permanent solution was found to the problem of silting in the port. No matter where the seawalls were placed and replaced, the harbor soon collected sand. But each new representation raised hope for a solution as the area near Agde became known in increasingly complex ways.

The insistent nature of the silting led to more careful consideration of silt accumulation in the canal itself, which was contributing to the load of particulate matter that was settling into the harbor. A number of small rivers and streams in the area between Carcassone and the Mediterranean had been tapped to provide water for the canal in this region, but these water courses carried from the steep nearby mountains runoff that was filled with mud and sand. At first, the water was sent directly into the canal, but this was almost immediately revealed to be a poor plan. The powerful floods that periodically plagued the region damaged the canal walls as surges of mud and debris crashed into the fragile ditch. The flood-driven materials either floated on the surface of the water (sticks and small logs) where it damaged vessels, or sank to the bottom of the canal (silt) where it clogged the waterway and required dredging. To solve the problems, these feeder streams were now either (if they were small enough) routed over slightly elevated stone containers at the side of the canal that held back debris and mud, or (if they were larger rivers) redirected into aqueducts, running either over or under the canal. Conduits (with doors) from the diverted rivers were designed to allow some of the water from these sources to enter the canal when it was needed. Drains were also built into the side of the main chan-

nel, particularly near these inputs, not only for expelling excess water that threatened to make the canal overflow in wet periods, but also to wash out some of the silt. Along most of the sides of the canal, ditches were dug parallel to the main channel to capture general runoff and keep excess water from the canal.[48] All these efforts were meant to reduce the myriad silting and flooding problems that plagued the canal, but particularly the Port de Sète. Nonetheless, storms ravaged it, and silt collected without cease. New soundings, land surveys, and harbor plans continued to be drawn, and the experts from the different traditions of representational practice and engineering experience were called in to help—without stable success.

The lack of a reliable port made trade down the whole length of the canal less appealing than it might have been. The high cost of paying tolls through the locks also contributed to keeping long-distance trade low. But the canal as a whole functioned well by the end of the 1680s, and short-distance trade through it was lively from the start. Commercial dreams and cartographic skills not only proliferated representations of the landscape in the area, but made a new landscape in the southwest that was identified with its canal. This in turn became part of the imagery of the region and of France.

THE CANAL DU MIDI

This story tells us a great deal about how cartographic learning and systems for representing the landscape were mobilized in the end of the seventeenth century for commercial and political purposes. They constituted cognitive tools that allowed French entrepreneurs, engineers, and laborers to achieve a project that was technically beyond the means of the period. Representational techniques from land surveying to ethnographic work were mobilized for the project, and provided means for reworking the landscape for advantage.

The engineering of the Canal du Midi or Deux Mers constitutes a good science studies story about social learning, scientific expertise, and state power. But it is also a story about entrepreneurialism in late seventeenth-century France. The entrepreneurs who built the infrastructure for the state in this period absorbed a great deal of the risk involved in the massive social changes that we call in retrospect the growth of the modern state or the development of state absolutism. They helped to rework the landscape in ways that transformed places into states, and made them something politically and economically new. They sought and were given economic benefits from their efforts. They took economic risks for economic gain. But they were interested less in taking risks than reducing them; they wanted to do things they knew they could do. Since they did not have the personal exper-

tise for such assessments, what kind of "knowing" did they rely upon to make good choices in their schemes? An answer perhaps lies in the understudied connections between representations of nature and commercial activity. If someone could see what to do to promote trade and make a map or plan for it, there was reason to invest in it. When Riquet had a map of the Montagne Noire and models to demonstrate his alimentary system, it was time to start building a canal. And so they did, and reworked this region of the southwestern France to make it a tribute to human ingenuity and territorial power.

Notes

1. See, for example, Marie-Joelle Paris, *Versailles: Le Grand Aqueduc de Buc ou de la manière de conduire les eaux au parc*. (Buc: Office municipal des associations de Buc, 1986), 47–58.

2. A. Marcet-Juncosa, " L'opposition catalane à P.P. Riquet" in Ed. Jean-Denis Bergasse, *Le Canal du Midi, Vol. 3: Des siècles d'aventure humaine* (Millau: Maury, 1984), 143–150. On 15 December 1662, Riquet wrote Colbert from Rousillon describing his ambitions for this project.

3. Archives du Canal (AC) Liasse 46, piece 1—"Edit créant un droit annuel sur les cabaretiers (hotelleries, cabartets, tavernes et marchands de vin) dan toute l'entendue du Languedoc; piece 2—arrêt du Conseil d'Etat ordonnant une imposition de 40,000 livres sur les contribuables aux tailles de la Généralité de Montauban en remmplacement du droit annuel sur les cabaretiers." 19 October 1671.

The local resistance to the sale of offices is illustrated in exchanges of letters between Colbert and Riquet mentioning the opposition he was facing from the elites in Toulouse, and reluctance to pay from Montpellier.

AC Riquet to Colbert 20 August 1670 mentions that the "scindics de Languedoc" are opposed to the sale of :

> offices des greffiers consulaires et de preudhommes. Mais comme . . . je vous envoyeray un arrest du conseil pour en ynterdire un, j'ay lieu de croise qu'aprés cet example vous trouverez toutes les facilités que vous pouvex désirer à en tirer les sommes qui vous doivent revenir de la ventes desdits offices.
>
> Je parleray au sieur de Bersan des advances que vous souhaitex qu'il vous fasse sur les gages des greffiers consulaires et preudhommes, encore que M. de Senes me mande que vous avez touché les trois quarts de revenu des deux année 1669-1670, et si je puis l'obliger à vous fournir quelque somme considerables je le feray voloniers.

AC Riquet to Colbert 1-10-7: The problems at Montpellier seem to have been less opposition to the sale of offices than routine non-payment of the fees for the sales.

4. For the opposition, see, AC Liasse 46. In AC Liasse 548 piece 2, there is an order from the intendant enjoining the communities near the canal's construction site to repair the roads to facilitate transport to these areas. 23 Mai 1669. AC, Liasse 191 describes the acquisition of lands. This is a listing of the sales of lands for the canal, which names the seller, the quality of land, the size of the parcel, and the price of sale. The land is valued by what is grown on it.

So, wheat fields are valued less than orchards and gardens. There is no mention of water rights in these early records, although there are some buildings included on the lands where the canal is to go. This is particularly the case in the area of Toulouse where the canal enters a populated area.

5. AC Liasses 35, 37, 39, 45, 46, 48, 191. It is important to keep in mind that although the *gabelle* in Rousillon was new, it was not given to Riquet just to finance the project. In fact, he was given this area to "farm" before he first proposed the canal to Colbert, and it was because of his success as a tax farmer that he was in a position to write to Colbert about his scheme on 15 December 1662.

6. The kinds of connections he had through the *gabelle* are visible in the list of those who invested both small and large amounts in the project. These were people with multiple ties to Riquet and politicians of many statuses. See Pierre Burlats-Brun and Jean-Denis Bergasse,"L'Oligarchie Gabelière, Soutien Financier de Riquet" in *Le Canal du Midi*, Vol. 4: Grands Moments et Grands Sites. 125–141.

7. L. T. C. Rolt, *Le Canal Entre Deux Mers* (Paris: Euromapping, 1994), 23–24.

8. For indication of the value placed on this project in this period and before, see AC Liasse 1.

9. For a discussion of the *mesnagement* tradition, see Chandra Mukerji, *Territorial Ambitions and the Gardens of Versailles* (Cambridge: Cambridge University Press, 1997), 41–42, 45; Thierry Mariage, *L'Univers de Le Nostre* (Bruxelles: Pierre Mardaga, 1990), 43. For more details of this political tradition and garden design see also Chandra Mukerji, "Bourgeois Culture and French Gardening in the 16th and 17th Centuries," paper presented at Dumbarton Oaks 1998, and to be published in Michel Conan (ed.), *Bourgeois and Cultural Encounters in Garden Art*, 1550–1850 Dumbarton Oaks 2001. For the relationship between this political philosophy and the Canal du Midi, see Chandra Mukerji, "The Modern State as Material Accomplishment: Territorial Culture and the Canal du Midi," paper presented at Bad Homburg 2000.

10. For a discussion of the work on the canal including the contract, wages, and working conditions, see Bertrand Gabolde, "Les Ouvriers du Chantier" in *Le Canal du Midi*, vol. 4, 235–239, and André Maistre, *Le Canal des Deux-Mers: Canal Royal du Languedoc 1666–1810* (Toulouse: Éditions Privat, 1998), 72–77.

11. Emmanuel Le Roy Laduric, *Montaillou: The Promised Land of Error*. New York: G. Braziller, 1978.

12. Rolt, *Le Canal Entre Deux Mers*, 72.

13. Maistre, *Le Canal des Deux-Mers*, 95–111.

14. Bruno Latour, "Visualization and Cognition: Thinking with Eyes and Hands," in *Knowledge and Society: Studies in the Sociology of Culture Past and Present*, ed. H. Kuklick and E. Landfed (Greenwich, Conn.: JAI Press, 1986) 6, 1–40.

15. This distinction between information and learning is crucial for understanding state power and the deployment of experts. Experts often work with partial knowledge and are asked for advice on which they can give only preliminary judgments. Nonetheless, states make their policies on these assessments, and they have, over many centuries, managed to maintain a certain level of legitimacy. Having good information helps, but it is not always possible to get. What is more important to states is the development and cultivation of learning systems—like the research branch of DOD. See Chandra Mukerji, *A Fragile Power: Scientists and the State* (Princeton, N.J.: Princeton University Press, 1989).

16. Paul Bondois, *Deux Ingénieurs au Siècle du Louis XIV: Vauban et Riquet* (Paris: Librairie Picard, n.d.); André Corvisier, *Louvois* (Paris: Fayard, 1983). For the risks of trying to build a canal in this region along with the desire to do it, see AC Liasse 1.

17. François de Dainville, *La Géographie des Humanistes* (Génève: Slatkin Reprints, 1969).

18. I have argued elsewhere that a system of distributed learning developed at this site and that it worked as a means of problem solving for the engineering of the canal. See Chandra Mukerji, "Distributed Cognition and the Canal du Midi," paper presented at the 1997 annual meeting of the American Sociological Association. I don't want to spend time here belaboring the point. I will not elaborate either the concept of distributed cognition, or how it should or should not be applied to this history. That is complex issue that requires a long argument in itself. For work in this tradition of analysis, see Edwin Hutchins, *Cognition in the Wild* (Cambridge: MIT Press, 1995). See also Philip Agre, *Computation and Human Experience* (New York: Cambridge University Press), 1997; Yjro Engestrom and David Middleton, *Cognition and Communication at Work* New York: (Cambridge University Press, 1996).

19. Anne Blanchard, *Les Ingénieurs du Roy de Louis XIV à Louis XVI* (Montpellier: Université Paul-Valéry, 1979), 42–54. See also Chandra Mukerji, "Engineering and French Formal Gardens in the Age of Louis XIV," paper presented at the University of Pennsylvania symposium "New Approaches to French Garden History," 1998. Unfortunately for the army, topographical mapping was a technically difficult discipline. The survey work itself was physically and cognitively taxing. It required attention to two dimensions of measurement (elevation as well as distance), and drew surveyors to work in rugged landscapes, trying to join lines of sight in environments in which it was often hard to see. There were drawing problems as well; contour lines had not yet been developed so there were no good standardized conventions for rendering elevations accurately. Still, military cartographers became skilled at noting localized changes in topography and came to know the landscape in these terms along France's borders. P. D. A. Harvey, *The History of Topographical Maps* (London: Thames and Hudson, 1980).

20. For material techniques and military engineering, see Alain Manesson Mallet, *Les Travaux de Mars . . .* (Amsterdam: Henri Desbordes, 1696); John Muller, *The Attack and Defense of Fortified Places. In Three Parts* (London: T & J. Egerton, 1791), particularly plates 9 and 11; M. Belidor, *Les science des ingenieurs dans la conduite des travaux de fortification.et d'architecture civile.* (Paris : Claude Jombert, 1729); Nicolas de Fer, *Introduccion à la Fortification dedié à Monseigneur le duc de Bourgogne* (Paris: Chez l'auteur dans l'Isle du Palais sur le Quay de l'Orloge à la Sphere Royale. avec. priv du Roy, n.d.); Pierre Rocolle, *2000 ans de fortification française*, tome I. (Limoges and Paris: Charles-Lavauzelle, 1973), 175–212; Sébastien Le Prestre Vauban, *De l'attaque de de la défense des places* (La Haye: Chez Pierre de Hondt, 1736). The importance of surveyors and the military engineers to the politics of the period was symbolic as well as practical. Military engineering had been a hallmark of ancient Rome. "Monuments to the greatness of Rome" were celebrated by Louis XIV and his contemporaries, and stirred them to use French soldiers for comparable work. The army engineers were first employed for the obvious jobs of building of ports, garrisons, and arsenals, but they were also used to improve the water supplies for Versailles and Paris, and in setting out drainage and flood control ditches around rivers and swamps, and laying out canals that flowed where rivers did not. All these projects required some survey work, and all of them showed up again on maps. Tantalizingly, these efforts reshaped precisely what was recorded on maps—the shape of the shoreline, the course of rivers, the topography, and the roads crossing the landscape. See Mukerji, "Engineering and French Formal Gardens in the Age of Louis XIV" 1998; John A. Lynn, *Giant of the Grand Siecle: The French Army 1610–1715* (Cambridge: Cambridge University Press, 1997); and Josef Konvitz, *Cartography in France, 1660–1848* (Chicago: University of Chicago Press, 1987).

21. Frances Yates, *The French Academies of the 16th Century* (Warburg Institute: University of London, 1947); Institute de France, *Académie des Sciences: Troisième Centenaire 1666–1966* (Paris: Gauthier-Villars, 1967), ch. 1.

22. The canal would work only if the segments met and the elevations worked. Alice Stroup, *A Company of Scientists: Botany, Patronage, and Community in the Seventeenth-Century Parisian Royal Academy of Sciences* (Berkeley: University of California Press, 1990), ch.1.

23. Mukerji, *Territorial Ambitions* 1997. For a discussion of this political approach and its effects on the region of Languedoc, see Maistre, *Le Canal des Deux-Mers*.

24. Bertrand Gabolde, "Revel: Des Eaux du Sor à la Rigole de la Plaine," *Le Canal bu Midi*, vol. 4, 241–244; François Gazelle, "Riquet et les Eaux de la Montange Noire," in *Le Canal du Midi*, 145–147; Malavialle, "Une Excursion dans la Montagne Noire," *Société Languedocienne de Géographie* Bulletin, part 2, 135.

25. Maistre, *Le Canal des Deux-Mers*, 72; Gazelle, "Riquet et les Eaux."

26. For the hydraulic expertise in Italy in the period, see Gazelle, "Riquet et les Eaux," vol. 4, 147–150; Malavialle, 120–121. For Andréossy's interest in Riquet and Languedoc, see Jean Robert and Jean-Denis Bergasse, "L'Étrange Destin des Andréossy," *Le Canal du* Midi, vol. 3, 199–201.

27. Rolt, *Le Canal Entre Deux Mers*, 24–27; Inès Murat, "Les Rapports de Colbert et de Riquet: Méfiance pour un homme ou pour un système?" in *Le Canal du Midi*, vol. 3 (Cessenon: J.-D. Bergasse, 1984), 108. For a discussion of demonstration and representation, see Mukerji, *Territorial Ambitions* 1997, ch. 7; Chandra Mukerji and Patrick Carroll, "Material Culture Methods and Historical Sociology," paper presented at the1996 annual meeting of the American Sociological Association.

28. Rolt, *Le Canal Entre Deux Mers*, 30–31; Maistre, *Les Canal des Deux-Mers*, 38–41; Murat, "Les Rapports de Colbert et de Riquet," 111–112.

29. Hubert Pinsseau, "Du Canal de Briare au Canal des Deux Mers: Origines et Conséquences d'un Sysème inédit de Navigation Artificielle" in *Le Canal du Midi*, vol. 4, 27–54.

30. For a discussion of Cavalier's work, see François Dainville, *Cartes anciennes du Languedoc, XVIe–XVIIIe siècles* (Montpellier: Sociète languedocienne de gèographie, 1961, 38–40); Robert and Bergasse, "L'Étrange Destin," 203.

31. Rolt, *Le Canal Entre Deux Mers*, 31. Dainville, *Cartes anciennes du Languedoc, XVIe–XVIIIe siècles*, 55, 60–61; M.L. Malavialle, "Une Excursion dans la Montagne Noire," *Sociètè Languedocienne de Gèographie Bulletin*, part 3, tome 15, 283–314. The first map published of the canal plan and its water supply was actually made by the géographe du roi, P. du Val. See Malavialle, part 4, tome 15, 436–439, 475–476.

32. Rolt, *Le Canal Entre Deux Mers*, 32.Some of the changes they initiated had to do with the route of the canal itself. Under their influence, Riquet abandoned the idea of making the Fesquel and Aude Rivers navigable, and instead agreed to dig a separate canal in these river beds to connect his new canal with the ancient Canal de la Robine, which could then carry boats to the Mediterranean. The reason for this shift was probably Bourgneuf's acquaintance with the Canal de Briare. He knew about the tie-ups in shipping that resulted from problems in navigating these wild rivers. Trade would be easier in a more contained set of canals.

33. Gazelle, "Riquet et les Eaux," 145–146; M. L. Malavialle, "Une Excursion dans la Montagne Noire," Part I. *Société Languedocienne de Géographie Bulletin*, tome XIV, 1891, 280–284.

34. Henri Enjalbert, "Les Hardinesses de Riquet: Données Géomorphologiques de la Région que Traverse le Canal du Midi," *Le Canal du Midi*, vol. 4, 129–142.

35. Dainville, *Cartes anciennes du Languedoc, XVIe–XVIIIe siècles*, 47. The idea of using the Sor River as a source of the water supply for a canal between the Garonne and Mediterranean had been discussed by a géographe du roi, Pierre Petit in 1663. See Malavialle, "Une Excursion dans la Montagne Noire," *Sociètè Languedocienne de Gèographie Bulletin,* part I, 273 ff.

36. Rolt, *Le Canal Entre Deux Mers*, 35–37; Froidour, *Lettre à Monsieur Barrillon Damoncourt, Conseiller du Roy en ses Conseils, Maître des Requestes Ordinaire de son Hostel, Intendant*

de Iustice, Police et Finances en Picardie, contenant la Relation & la description des Travaux qui se sont en Languedoc, pour la communication des deux mers, 9–10; Gazelle, "Riquet et les Eaux," 162–164; Dainville, *Cartes anciennes du Languedoc, XVIe–XVIIIe siècles,* 1961, 47; Malavialle, "Une Excursion dans la Montagne Noire," *Sociètè Languedocienne de Gèographie Bulletin,* part 2, 146. Is this the route that Clerville opposed, according to Malavialle (Part I, p. 259)? Although Riquet's project was vindicated by the study, his plan was not adopted without revision. While the commission was checking surveys and Riquet was preparing the rigole *d'essai*, the main proposed *rigole* was rerouted. We have no direct evidence about the socio-cognitive context for the switch. Clerville was the first to make note of it in a plan for Colbert, but the new channel seemed more the work of a local surveyor than a fortress designer; it followed the contours of the land more exactly, requiring a longer course but fewer of the costly tunnels and less complex terracing that military engineers tended to build. Still, Campmas was not part of the survey team; Andréossy was Riquet's expert there; and we have no knowledge of the backgrounds or contributions of the two unknown surveyors in the party. On the other hand, the canal engineer, Bourgneurf, was on the mountain at the time, and he tended to favor simple systems that were less prone to break down. Whatever the dynamics that led to it, all we know is that the shift occurred when the commission's survey team was working on the mountain, checking elevations and routes for the waterworks; any or all of the experts may have contributed to this change of plans. The resulting *rigole* followed a path between the original one developed by Campmas, Andréossy and Riquet, and the suggestions being made for revision by the commissioners. In this way, it was apparently (even from the scanty evidence we have of its design) a socially negotiated solution to a technical problem in the water supply. The alimentary system was changed more dramatically and explicitly by a redesign of the reservoirs on the Montagne Noire. Riquet originally proposed a set of small reservoirs to capture and hold the water, but Clerville thought it would be simpler to construct one great holding facility at Saint-Ferréol. There was a rock base at the end of this high valley where the Laudot River ran; a huge dam could be built on such a solid base and provide, Clerville surmised, all the needs of the canal. The great dam erected at Saint Ferréol was a majestic piece of military engineering, designed for strength using three distinct stone walls filled between with compacted dirt. This was a common pattern of construction at the fortresses built by French military engineers. The tailoring of the design to local material conditions was also typical of military engineering in the period, and so it should be no surprise that Clerville would have made such a proposal. The dam, however, was not just a creature of the military. It contained elements of hydraulic engineering that were also advanced for the period. There was a complex set of sluices for different purposes. Some were near the top for letting out water for use in the canal; at the bottom was a door to drain the reservoir for periodic cleaning, and to let out the inevitable buildup of silt on the floor of the valley. There was a diversion channel, too, for carrying off excess water or for diverting the river when the reservoir was being cleaned or repaired. The great dam, then, was constructed using principles from both civil and military engineering. The holding system originally proposed by Riquet, with its complex set of small reservoirs, would have resulted in less reliable dams built on more unstable surfaces; the Saint-Ferréol plan was in this way an improvement. But in fact the one reservoir was not adequate to its task. Ironically, the great fortress designer Vauban, after he had replaced Clerville as France's top military engineer, was brought in to correct faults in the system, and recommended the construction of additional small reservoirs precisely where Riquet first wanted them. Once again a combination of civil and military engineering-surveying was used to improve the alimentary system. See also Gazelle, "Riquet et les Eaux," *Le Canal du Midi*, vol. 4, 155–158, 169; Froidour, *Lettre à*

Monsieur Barrillon Damoncourt, Conseiller du Roy en ses Conseils, Maître des Requestes Ordinaire de son Hostel, Intendant de Iustice, Police et Finances en Picardie, contenant la Relation & la description des Travaux qui se sont en Languedoc, pour la communication des deux mers, 16–31; Malavialle, "Une Excursion dans la Montagne Noire," *Sociètè Languedocienne de Gèographie Bulletin*, part I, 266–272.

37. Details of the *rigole d'essai* are contained in AC Liasse 2.

38. For some of the literature that started to appear in the late seventeenth and eighteenth centuries on hydraulic engineering, see, for example, Bouillet, *Traite des Moyens de rendre les Rivieres Navigables avec plusieurs desseins de jettées. . . . Ouvrage tres-utile à tous les Ingenieurs, & à tous ceux qui semêlent de Bâtimens & de Machines.* (Paris: Chez Estienne Michallet, 1693); Belidor, *Architecture Hydraulique seconde partie qui comprend l'Art de diriger les eaux des la Mer & des Rivieres à l'avantage de la défense des places, du Commerce & de l'Agriculture,* (Paris: Jombart, 1756). For the work done on ports in the period, see Josef Konvitz, *Cities and the Sea.* Baltimore: Johns Hopkins Press, 1978.

39. Alain Degage, "Le Port de Sète: Proue Méditerranéenne du Canal de Riquet," in *Le Canal du Midi*, vol. 4, 265–285.

40. For the riches of the region, and their importance in the discussions of the canal in Toulouse, see AC Liasse , piece 14- Avis à Messieurs les Capitouls de la Ville de Toulouse et reponse par Iean de Nivelle, ancien Capitaine Chassvants du Canal. 1667, 7:

> Pour rendre ce Canal Royal encore plus glorieux & donner une tres grande commodité au commerce qui se fit au Royaume d'Espagne pour porter les laines de France, & de faire tranporter les marchandies & dentrées de France & les Royaumes là, faire porter sur la riviere de Garonne depuis sa source, les marbres precieux de toutes sortes de couleurs, & jaspres de plus beaux qui soient en l'Europe, les pierres à taille pout bastir, le bois à construire les maisons & à faire des Vaisseaux qui faire porter sur la riviere de Lariege, le fer & le jayer tiré des Montagnes de Foix desdites Pirenées *** seroit necessaires de faire un Canal depuis la riviere de Garonne au dessus de moulin Chasteau, d'environ deux ou 300 toises de pong pour joindre le Canal Royal, pour lequel il ne faudroit consruire qu'une seule écluse contre la Riviere pour recevoir l'eau necessaire pour porter les Batteaux au Canal Royal.

41. For a discussion of the political economy of the region during this period, see Maistre, *Les Canals des Deux-Mers*, 15–33.

42. Rolt, *Le Canal Entre Deux Mers*, 35, 49, 76–77; Alain Degage, "Le Port de Sète: Proue Méditerranéenne du Canal de Riquet," *Le Canal du Midi*, 265–285. See also Froidour, 35–37; Froidour, *Lettre à Monsieur Barrillon Damoncourt, Conseiller du Roy en ses Conseils, Maître des Requestes Ordinaire de son Hostel, Intendant de Iustice, Police et Finances en Picardie, contenant la Relation & la description des Travaux qui se sont en Languedoc, pour la communication des deux mers*, 48–72 who also participated in the discussions about designing Sète. He brought from his forestry experience skills in civil surveying and the politics of engineering the landscape. Dainville, "Cartes anciennes du Languedoc, XVIe–XVIIIe siècles (Montpellier: Sociètè languedocienne de gèographie, 1961) 56–62.

43. AC 10-10-70- Letter from Colbert to Riquet about sending La Feuille to Holland.

44. Louis de Froidour, *Lettre à Monsieur Barrillon Damoncourt, Conseiller du Roy en ses Conseils, Maître des Requestes Ordinaire de son Hostel, Intendant de Iustice, Police et Finances en Picardie, contenant la Relation & la description des Travaux qui se sont en Languedoc, pour la communication des deux mers*. (Toulouse: Chez Dominique Camusat, 1672).

45. M. Devèze, "Une Admirable Réforme Administrative: La Grande Réformation des Forêts Royales sous Colbert (1662–1680)," in *Annales de L'École Nationale des Eaux et Foreêts*

et de la Station de Recherches et Expériences. (Nancy: Ecole Nationale des Eaux et Forets, 1962); André Corvol, *L'Homme et l'Arbre sous l'Ancien Régime* (Paris: Economica, 1984).

46. Froidour, *Lettre à Monsieur Barrillon Damoncourt, Conseiller du Roy en ses Conseils, Maître des Requestes Ordinaire de son Hostel, Intendant de Iustice, Police et Finances en Picardie, contenant la Relation & la description des Travaux qui se sont en Languedoc, pour la communication des deux mers*, 1672.

47. Ibid.

48. The rebuilding of the canal is described in AC Liasse 16- Travaux d'amélioration. These documents are mostly describing work by Niquet, but some was by Vauban.

'Cornelius Meijer inventor et fecit'

On the Representation of Science in Late Seventeenth-Century Rome

KLAAS VAN BERKEL

Among the many explanations of the so-called Scientific Revolution, one of the more attractive relates to the temporary lowering of the social divide between the technical expertise of the craftsmen and the theoretical knowledge of the scholars. In several countries in Europe, architects, navigators, craftsmen, and surgeons contributed both to the construction of scientific knowledge and to the introduction of new methods and instruments. Italian engineers and architects led the way in the fifteenth century, but even as late as the last quarter of the seventeenth century an ordinary Dutch merchant like Antoni van Leeuwenhoek was able to stupefy the Royal Society of London with his most detailed microscopic observations of "small animals."

The contribution of these engineers, merchants, and craftsmen to the new science was not restricted to unconventional ideas, unorthodox methods, or newly invented instruments. A vital aspect of modern science is also the introduction of new ways of representing nature and science. Whereas mathematical sciences in principle needed no more than some crudely drawn diagrams and figures, the experimental sciences depended heavily on the skills of artists who could represent the newly discovered worlds in a way that was convincing for those who were not present. The credibility of the new experimental science not only required statements of trustworthy eyewitnesses and elaborate verbal descriptions, but precise, lifelike, and attractive visual representations. Precise technical drawings were not enough (not yet, at least); seemingly irrelevant ornamental details and a lifelike setting of the configurations were just as important. In a sense, precisely these irrelevant aspects of the representation were the most essential because more than anything else they generated the illusion of lifelikeness that mattered so much to the representatives of the new science. Therefore, the craftsman who was also an artist could be of utmost

importance for scholars and scientists who wanted to promote experimental natural philosophy.[1]

A little-known, but intriguing example of the craftsman who also operated as an artist and cooperated with practitioners of experimental science is offered by a near contemporary of Leeuwenhoek, a Dutchman called Cornelis Meijer. He was born the son of a humble wheelmaker in Amsterdam, but in Rome he rose to the the position of a distinguished member of the Accademia Fisicomatematica, the most important local scientific society. He was regarded as a successful engineer and an expert in astronomy, but he was also valued for his contacts with painters and artists and, more to the point, for his own artistic talents. In the 1680s and 1690 he published lavishly illustrated books in which he documented his own inventions, and elaborated on some of the experimental designs of the Accademia Fisicomatematica. As a would-be astronomer he may not have left his mark on seventeenth-century science and the scientific circles he associated himself with may not have become as famous as the Royal Society or the Académie des Sciences, but still his career is instructive for the value even rather conservative scholars in a place like Rome attached to a lifelike representation of their experimental investigations.

THE RISE OF CORNELIS MEIJER

Cornelis Meijer is an unknown figure in the history of science, but in the history of art the experts are not unfamiliar with his name. Actually, the first historian ever to devote some serious attention to Meijer was an historian of art, the assistant director and future director of the Dutch Historical Institute at Rome, G. J. Hoogewerff. His 1920 article on Meijer in the art historical journal *Oud-Holland* still is the essential point of departure for all research on Meijer.[2] For art historians, Meijer's claim to fame was his relation to the famous painter Casper van Wittel, well-known for his *vedute*, his views of Rome and its surroundings. Van Wittel went to Rome just after Meijer had arrived there and was hired by Meijer to execute the drawings for the report Meijer had to write concerning his investigations into the navigability of the Tiber. There is some discussion about the relative share of Meijer and Van Wittel in drawing the illustrations in this report, of which several copies and versions exist.[3] Some claim that Meijer can be held responsible only for the cruder drawings, the more sophisticated ones being ascribed to Van Wittel. But the technical details in even the most refined drawings are unmistakenly inspired by Meijer (who also hired other artists to work out his drafts), and, considering his involvement in the representation of science in the context of the Accademia Fisicomatematica somewhat later, it is quite likely that his

share in the cooperation with Van Wittel was more important than most art historians are prepared to admit.

Cornelis Meijer, born in Amsterdam in 1629, belonged to the Lutheran community in Amsterdam, a fact that might explain why later in his life he so smoothly changed religion and turned into a pious Roman Catholic. (The history of the Lutheran community in Amsterdam is full of reconversions to Roman Catholicism.) Not much is known of his early life, but he seems to have been an ambitious craftsman who applied for patents for new technical equipment by the early 1670s. He apparently moved in semiscientific circles, discussing hydraulics with university scholars and participating in the research of Jan Swammerdam. If we are to believe what he told his Roman audience much later, he even acquired enough riches in Holland to collect a large cabinet of curiosities, containing for instance quite a number of precious stones; indeed there is some archival evidence that Meijer's claim is correct. On his departure for Italy, he had his cabinet taken care of by some of his relatives.[4]

In 1674 Meijer left Amsterdam and went to Venice, where he tried to sell his technical expertise to the Republican government. Why he did so is not quite clear. In Rome, Meijer told his friends that he had come to Rome in the Holy Year 1675 to obtain the indulgences the Church had promised to those who repented their sins, converted to Catholicism, and visited a specified number of churches in Rome. But Meijer, while still in Amsterdam, had printed a leaflet that showed all kinds of hydraulic constructions and is explicitly addressed (in Dutch, that is!) to the Venetian government.[5] Therefore it seems more likely that Meijer's main intention was to go to Venice to make a profit out of his technical expertise and that the excursion to Rome (where he would stay for the rest of his life) was just a side trip.

Venice had been a longtime ally of the Dutch Republic in its resistance against Spanish tyranny and popish imperialism. Since the city was confronted with the same problems as the Dutch Republic—rivers and harbors that were silting up, low-lying farmland that had to be drained, and so forth—Dutch engineers found ample employment in Venice.[6] Meijer succeeded quite rapidly in his plans. Some of his proposals were tried and adopted, and Meijer was put in charge of all the operations. He also obtained the official title of engineer, a title he valued even more than the monetary gains to be made in Venice.

However, in April 1675, before Meijer even had started to execute his plans, he left Venice for Rome. He promised the Venetian government to return as soon as possible in order to supervise the clearing of the harbor, but in Rome he found new opportunities for his engineering skills and in the end never returned to Venice. In Rome, Meijer became involved in a complicated project regarding the defense of the well-known Strada (or Via)

Flaminia against the Tiber.[7] North of Rome, the meandering river threatened to undermine the road that led straight to the Porta del Popolo, which most pilgrims took as they entered the Eternal City. Clement IX (1667–69) had ordered the best engineers and architects in Italy to devise a plan to rescue the threatened Via Flaminia. A number of them presented their plans to the cardinals in charge of the project, and the competition was won by the young Roman architect Carlo Fontana, a pupil of Bernini. But the pope died, and the new pope, Clement X (1670–1676), hesitated; according to his advisors, Fontana's plan was too expensive. Then, as Fontana and the cardinals were still discussing the details of the project, Meijer came along and suggested, through the Venetian ambassador to the Holy See, a completely different construction to check the river. Since Meijer's plan was indeed less expensive than Fontana's, the pope decided to put Meijer in charge of the rescue operation, passing over Fontana. In March 1676 Meijer began the work by first removing some obstacles from the river bed and then driving a large row of piles in the river, in this way deflecting its current, which from then on no longer threatened to undermine the Via Flaminia (see fig. 11.1). With this row of piles, in Italian a *passonata*, Meijer managed to do what a number of renowned Italian architects had not been able to do. All of a sudden, he was a well-known figure in the world of Roman architects and engineers.[8]

Not long after the beginning of the construction of his *passonata*, the pope also asked Meijer to concern himself with another complicated problem for which Italian engineers had been unable to find a workable solution. Clement X was very eager to make the Tiber suited for navigation, since this would greatly stimulate trade and commerce in the papal dominions. Now that Meijer had proved his abilities, he of course seemed to be the perfect candidate for writing a report and making proposals to improve the navigability of the Tiber. Although Meijer was eager to return to Venice and perhaps to Holland after finishing his commission in Venice, he was more or less forced to stay in Rome and to accept the pope's orders. During the construction of the *passonata*, Meijer had spent—as was common in those days—some of his own fortune to pay workmen and buy materials necessary for the construction. Of course the pope had promised to pay for all the expenditures and to reward him with an additional and considerable amount of money, but Meijer soon discovered that unlike the Venetian government, which had paid him on the spot, Roman officials were very slow in paying their bills. Only by accepting a second commission could Meijer hope to regain what he had paid out of his own pocket for the *passonata*. Perhaps that was the way papal officials strengthened their ties with their clients without paying them what they were entitled to.

Within a few months, Meijer had traveled all the way to Perugia, had seen what obstacles there were and had devised plans to overcome all these

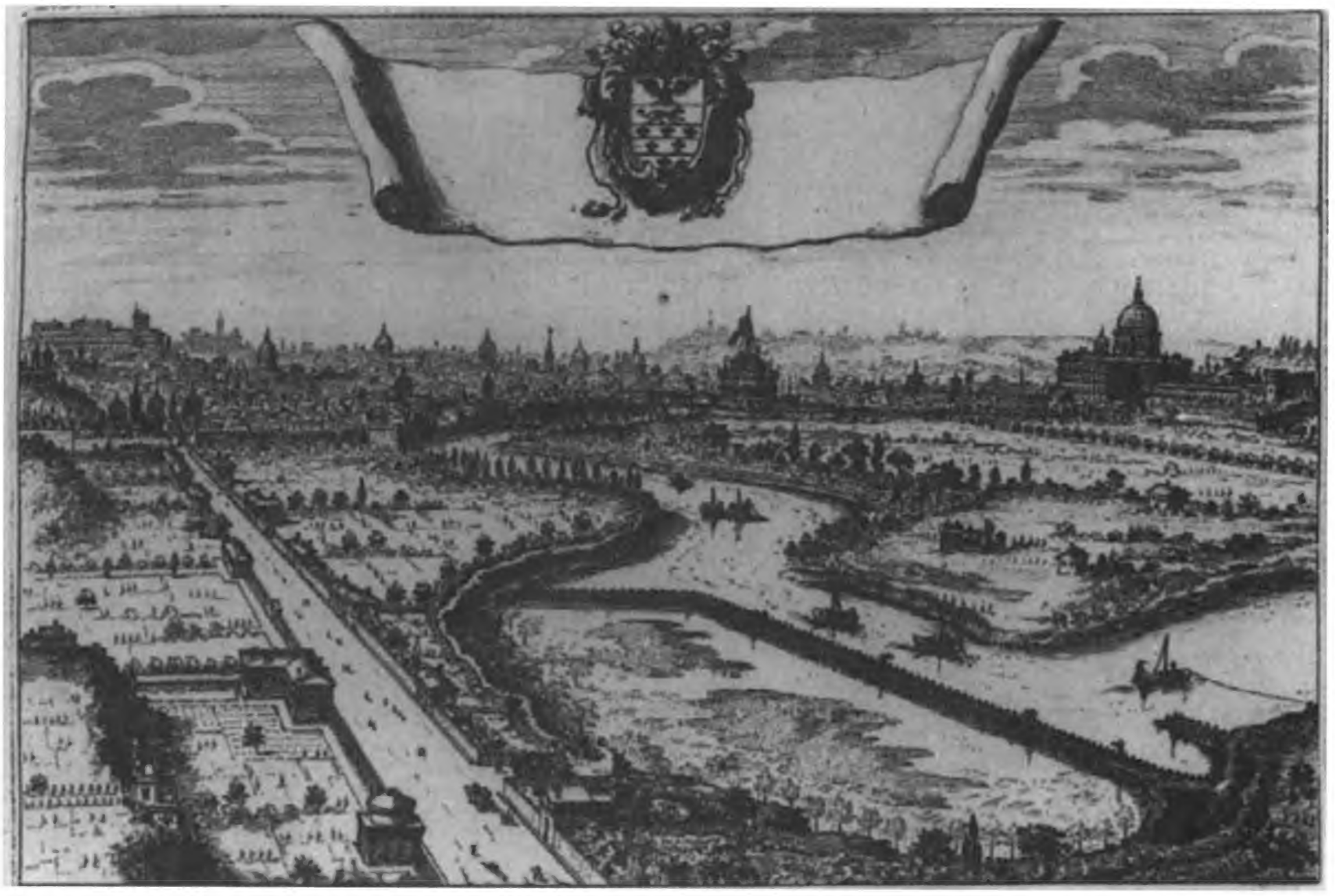

Figure 11.1 A view of Rome including Meijer's *passonata* in the Tiber. From Cornelis Meijer, *Delinationi con discorsi delle Reparationi* (Rome, 1670). Copyright © Amsterdam University Library.

difficulties. With the help of Caspar van Wittel and some other artists, he composed an extensive report on the project and offered it to the two cardinals who were in charge. The first version was written in Dutch and Italian, a second one in Italian only. Meijer did not speak or write Italian fluently enough to be able to write the report himself, so an assistant had to translate the Dutch text into Italian.[9] But before the report was finished, Clement X died, and a new pope was elected: Innocent XI (1676–89). With the new pope new clients, including architects, engineers, and artists, came to Rome, so Meijer had to do all his best not to fall into disfavor with the new pope and his courtiers. In this respect he succeeded, but his plans were not executed, and it is almost certain that despite his pleas and requests, he never was reimbursed for all the expenditures made during his travels to and from Perugia. This continual effort to regain some of his money kept extending his stay in Rome beyond what he had anticipated; his intention to stay in Rome for a longer period of time is also illustrated by the fact that about this time he sent for his wife, and that she left Amsterdam for Rome.

The construction of the *passonata* had turned the foreigner from Holland into a public figure in Rome. Perhaps his fame was also enhanced by the bitter dispute that erupted once the *passonata* was under construction. Technically the *passonata* was a success, but it also made him a number of influential

enemies, who tried to block his further career in Roman society. In a sense, Meijer's career in Rome after 1678 was a constant fight to defend the *passonata* and his own reputation against detractors and envious critics.

The most important of these enemies was the architect Meijer had displaced in the project that made him famous: Carlo Fontana, distantly related to the famous sixteenth-century Roman architect Domenico Fontana and one of the most promising pupils of the great Bernini. It must have been a severe blow to the ambitious Fontana that a total stranger, a Dutchman who could not even speak Italian, was commissioned to do—and did, apparently successfully—what Fontana had very much wanted to do. From the start of the operations, he and others (including other pupils of Bernini) tried to prevent the execution of Meijer's plans. They complained about his materials, the constructions, the amount of money it would cost. Several times during the construction of the *passonata*, the work had to be stopped so the papal administrators could do some investigations. Every time, Meijer was proved right and his critics proved wrong.

The result of what proved to be only the first round in this conflict between Meijer and Fontana was the publication, in 1679, of a small book on the construction of the *passonata*. Actually, it is not a book, but rather looks like a portfolio collection of some engravings representing Meijer's work on the *passonata*. It is dedicated to the pope and has an introduction in which Meijer tells his readers why he published his inventions, but there is no title or title page. The most complete copy I was able to consult includes two broadsheets concerning two completely unrelated plans, first to drain the Pontine marshes and second to dig a new canal between Rome and the sea in order to avoid the silted-up mouth of the Tiber. In his introduction, Meijer makes it clear that his "book" is meant as a simple and true record of what had been accomplished in building the *passonata*, by no means glorifying the man who had devised it. "By presenting this to the public eye, I do not pretend," Meijer said, "to acquire the reputation of a learned and scientifically trained person" ("d'acquistare nome d'addottrinata, ò scientificata persona").[10] Nevertheless, this booklet was an effective means to defend his reputation and his *passonata*.

The booklet was only the first move in a long struggle with Fontana. Evidently, Meijer did also worry about his work on the navigability of the Tiber, fearing that others might publish his inventions without duly acknowledging his part in the project. He therefore decided to write a more extensive report on his engineering skills, including both his construction of the *passonata* and the solutions for the problems encountered by ships traveling on the Tiber between Rome and Perugia. The first edition of this book, titled *L'arte di restituire a Roma la tralasciata navigatione del suo Tevere*, was published in 1683 by the printing office of the Camera Apostolica. A second edition, or so it seems, was published in 1685.[11]

Actually, there is some reason to believe that the second edition was not a second edition at all, but just the completed version of a book that was published partially in 1683. On the title page of the "first" edition, the Camera Apostolica is mentioned as the printing office, but at the end of the book a private publisher is mentioned, Lazzaro Varese. Varese is also mentioned as the printer and publisher of the "second" edition, but it is more likely that during the publishing of the book Meijer changed publishers and that when the book was complete in 1685, he had the publisher print a new title page with the name of the new printer. This seems to indicate that Meijer had some urgent reason not to wait until the book was complete, but to publish the first part upon its completion. And indeed he had every reason to speed up the publication, because in 1683 Fontana once again went public with an attack on Meijer's *passonata*. After 1678–79, Fontana had become silent on the *passonata*. Apparently Meijer had done a fine job, and the destruction of the banks of the Tiber no longer threatened the Via Flaminia.[12] Behind the *passonata* some of the ground once lost to the river was reclaimed, making further losses improbable. In early 1683, however, Fontana and his followers charged Meijer once again with having used the wrong material and with having driven the piles too shallowly into the bottom of the river and so on. According to Fontana, it was just a matter of weeks or months before the *passonata* would collapse, giving free reign to the river again and eventually destroying the Via Flaminia. The pope was alarmed and ordered a careful investigation into the firmness of the *passonata*. Curiously enough, Fontana himself was put in charge of these investigations, and he immediately started to drill holes into the *passonata* in order to establish whether they were rotten or otherwise weakened. Meijer, who had denied all the charges, protested and argued that exactly by investigating the *passonata* in this way the investigators were destroying his constructions, and he urgently called for a halt in the investigations. The papal administrators accepted his protests and ordered Fontana to stop the investigation. In the end, it was shown that the *passonata* was as healthy as could be and that there was no need to be afraid of its being ruined by the river. But apparently, Meijer did not feel satisfied and once again resorted to the means of publication to establish his reputation, now not only as an experienced craftsman. He hastily collected his inventions and published his *L'arte di restituire*.

In a sense, this book is of course a direct continuation of his efforts in the 1670s to persuade future employers to hire him and assign him certain technical projects. Although it is lavishy illustrated, the book (in three parts) essentially consists of a series of separate engravings (or series of engravings) with more or less extensive and more or less scholarly comments. The 1683 book is much more sophisticated than the 1674 broadsheet or the 1679 file, but the format is essentially the same. As can be seen from the dating of

some of the engravings, Meijer used many old engravings for his new book, replacing the explanations by new comments, but hardly changing the engravings themselves. His *L'arte di restituire*, therefore, is still essentially a collection of advertisements of an ambitious craftsman-engineer for whom visual representations of his plans and projects were more important than the comments and explanations.

On the other hand, elements of the book suggest that it is much more than the sample book of an engineer. First, the high quality of the engravings is quite remarkable. Almost all of them bear the inscription "Cornelius Meyer inventor & delineavit, Io.Bapt. Falda sculpsit," which indicates that Meijer hired an expert hand only to engrave the drawings, not to draw the pictures themselves.[13] Yet some of the engravings bear the inscription "Cornelius Meyer inventor et fecit," suggesting that he did execute the engravings himself, without the help of other artists. Meijer was no member of the Dutch artistic brotherhood in Rome, the Bentveughels, but he evidently had talent and moved in these circles. His engravings of technical and scientific instruments are remarkable for their fine details of surrounding persons and architectural background. It looks as if Meijer wanted to impress his readers not only with his technical skills, but also with his artistic talents, or, what is more intriguing, to use his artistic talents to create an atmosphere in which his mechanical expertise was much more easily accepted by the Roman elite.

Second, the book, especially the third part of it, contains some projects that are completely new and seem to indicate a new social and intellectual milieu in which Meijer moved. For instance, he proudly presents some of the technical projects executed for the grand duke of Tuscany, Cosimo III, in Florence and some of the Tuscan harbors. Even more interesting are the engravings of fountains, scales, couches and, quite surprising, the beautiful designs for reconstructing the main squares of Rome. On some of these squares former popes had already erected an obelisk, but now Meijer wanted to use these obelisks as sundials or stardials and to decorate them with additional sculptures or new pavements. Rather delicate was the proposal for a completely new pavement of the St. Peter's Square, one of Bernini's greatest achievements. Around the famous obelisk (relocated in the 1580s by Carlo Fontana's distant relative Domenico Fontana) Meijer wanted to decorate the pavement with the four systems of the world that were being discussed by scholars at that time, the systems according to Ptolemy, Tycho (both of them acceptable to the Church), Copernicus, and Descartes (both unacceptable) (fig. 11.2). Although strictly spreaking Copernicus's book had not been put on the Index in 1616 and even Jesuit mathematicians were allowed to discuss Copernicus as long as they considered his system as a purely mathematical hypothesis, it was still very uncommon, to say the least, to confront the pope with these world systems.

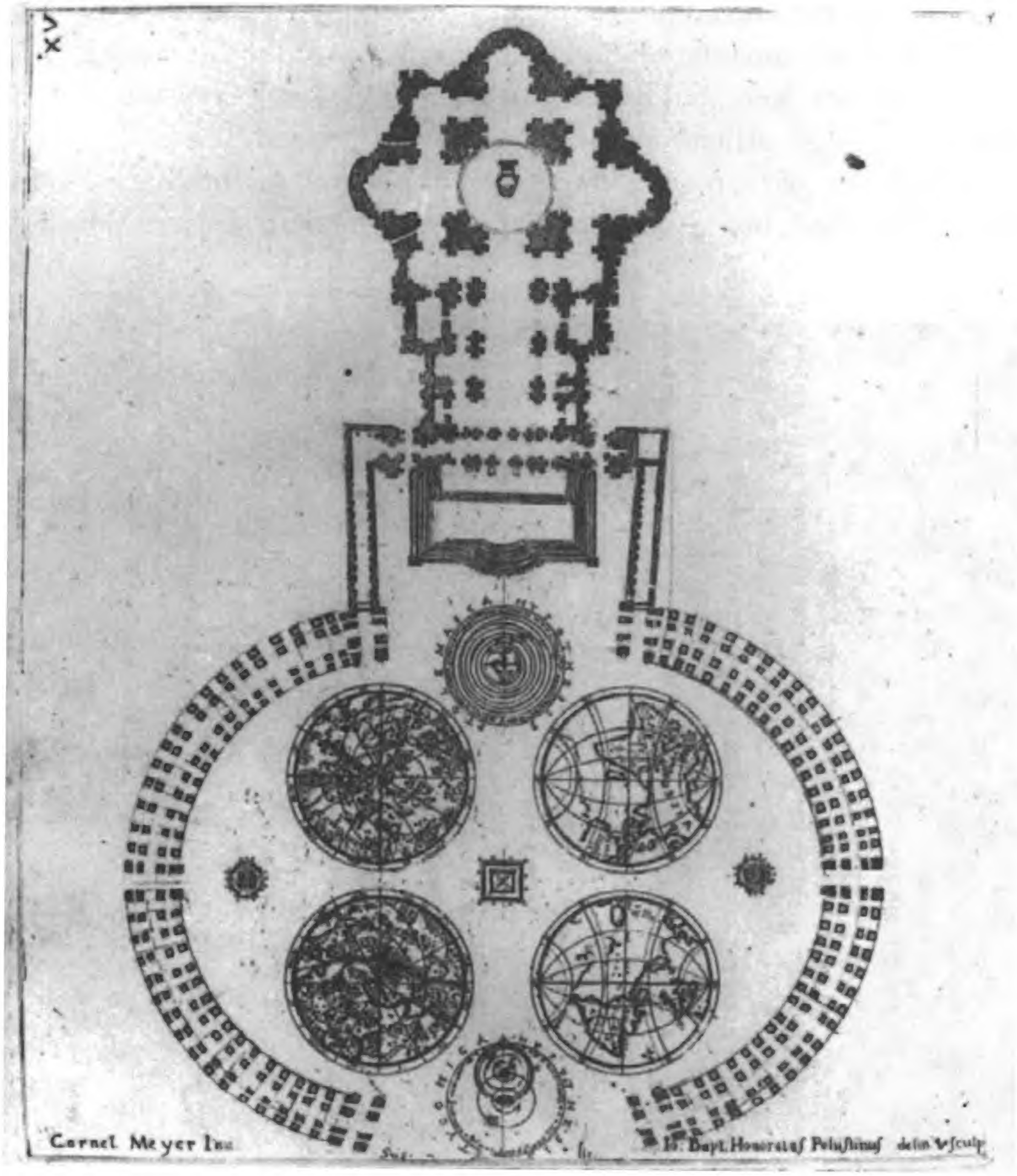

Figure 11.2 Meijer's plan for a new pavement for St. Peter's Square, displaying the Tychonic and Ptolemaic systems of the world (in the text, he also included the Copernican and Cartesian systems). From Cornelis Meijer, *L'arte di restituire* (Rome, 1685).

THE ACCADEMIA FISICOMATEMATICA ROMANA

The reason for introducing these architectural designs with their scientific contents is elucidated by Meijer himself in the explanation belonging to his engraving of a balance for establishing whether a crown was made from gold or silver (Archimedes's famous device) (figs. 11.3 and 11.4). While he was writing his book on the Tiber, he says, some high officials at the papal court stimulated him to include some of these other inventions too. Evidently, he had established relations with these courtiers during his negotiations regard-